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DATA ON THE USE OF CONSTANT LEVEL BALLOONS TO MEASURE THE HORIZONTAL MOTION IN THE ATMOSPHERE

From C. B. Moore

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A. Gaalswyk

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DATA ON THE USE OF CONSTANT LEVEL BALLOONS

TO MEASURE THE HORIZONTAL MOTION IN THE ATMOSPHERE.

SUMMARY

In the course of Navy-sponsored investigations of cosmic rays and other atmospheric phenomena, the authors at General Mills, Inc. have made many constant level balloon flights on the standard meteorological surface of 300 mb (nominally 30,000 feet). The tracks of these flights are of general meteorological interest, as they are believed to delineate the actual trajectory of an equivalent mass of air travelling on a constant pressure surface. Some of the original flight data are presented for the information of other investigators of air motions, to illustrate the application of constant level balloons to meteorological problems, particularly atmospheric diffusion and the variability of the wind. Suggestions are made of the significance of the data presented, and further experiments are proposed which might result in a better understanding of the mechanisms of air motion. Possible applications of constant level balloons in routine observations to obtain representative measurements of wind velocity are set forth.

INTRODUCTION

The determination of air trajectories is an essential quantity needed in modern meteorology. No forecaster can expect great success without a knowledge of the area of origin of tomorrow's weather, as the weather of tomorrow is in a large part determined by the atmospheric conditions of today, at points upwind. Presently, meteorologists attempt to determine air flow by the application of hydrodynamics to upper air data observed simultaneously over a large region. Using the instantaneous observations of wind and pressure fields, efforts are made to determine the air flow by the integration of all these data with time. However, the integrated trajectories thus obtained do <u>not</u> provide a satisfactory picture of the motion of the air.

The fundamental reasons for this appear to be the non-representativeness of the present upper air observations and the difficulty of obtaining a sufficiently accurate model of the atmosphere which is simple enough to be worked with.

The wind observations determined by use of ascending sounding balloons in the weather services appear to be not sufficiently representative of the true air motion at any one level for at least three reasons:

1. Eddy motions, superimposed on the field of translation, introducing dispersions and variability into the instantaneous observations. This effect when coupled with the short sampling time of rawin observations, results in wind measurement distributed about the representative air translation value.

2. Inherent limits of accuracy of the older wind measuring systems, such as pibals and rawins, obtained from the SCR658. However, a study by Rapp ( ) shows that the winds measured by newer military systems have a greater precision than is afforded by the wind variability over time and space.

3. Non-synopticity of winds. This arises from operational considerations whereby the wind observations may depart from simultaneity at various stations by an hour or more (Gabriel & Belucci).

The combined effect of the limiting factors listed has caused one observer to conclude that a wind report of 30 knots from 270° must be considered as possibly indicating a true wind somewhere between 21 and 40 knots blowing from between 240 to 300° (Machta). With such lack of precision, meteorologists frequently disregard the reported wind when analyzing upper level charts and computing trajectories.

Lacking trustworthiness and direct wind observations, the "geostrophic" wind derived from pressure observations is widely used in dynamic meteorology. This "wind" in its simple form is derived from the horizontal pressure gradient by means of the following relation and assumption:

$$\text{Geostrophic velocity} = \frac{\text{pressure gradient}}{\text{air density x coriolis force}}$$

The coriolis force (λ) is a function of the earth's rotation (ω)

and the latitude (ϕ) of the air parcel. ($\lambda = 2\omega \sin \phi$)

$$\text{hence V geostrophic} = \frac{\partial p}{\partial h}\left(\frac{1}{\rho\lambda}\right)$$

The assumptions used in this relation are:

a. The vertical velocity of the air parcel is negligible.

b. No frictional stresses exist.

c. The isobars are straight, parallel and the wind blows parallel to them at constant velocity, i.e. the accelerations are zero.

Obviously these assumptions cannot be met in operational meteorology. Therefore, a wind so estimated will be defective according to the deviations from the assumption.

In addition, in the measurement of the pressure gradient itself lies possible sources of error due to the necessarily inexpensive construction of the radiosonde instruments as well as the systematic and operational errors in measuring atmospheric pressure and temperature. The errors permitted in a radiosonde measurement of pressure may exceed 4 mb. These errors in pressure measurements on the 300 mb surface at two different stations may cause a wind error of 8 mb at 300 mb $\sim$ 600 feet 2 sta 300 miles apart cross isobar with Δh for 300 mb level = 600 ft. Geo wind = 75 knots Δh = 0 $\Rightarrow$ geo wind = 0 $\therefore$ 100% wind error.

In view of this, it appears that a trajectory which is obtained by a forecaster using non-representative data smoothed subjectively and integrated, using non-valid assumptions <u>cannot</u> be expected to define the air flow accurately.

Needed, therefore, is some way of <u>naturally</u> integrating these transient effects into a simpler overall picture of atmospheric motion. Trajectories obtained from constant level balloons have been suggested as one fundamental approach.

STUDIES WITH CONSTANT LEVEL BALLOONS

In an effort to study geostrophic departures, Durst made use of "constant level" rubber balloons in 1943 and 1944. The experiments were of great interest despite the fact that the balloons did not remain aloft very long and were not well stabilized on a constant pressure level (variations of 25 mb over one-half hour intervals are reported).

More recently, the development of instrumented constant level plastic balloons has been reported by Spilhaus ( ). Significant trajectory data have now been obtained from these balloons both by New York University and General Mills investigations. Three sets of experiments involving air trajectories are described here.

In the first of these, actual balloon trajectories are compared with the "hindcast" trajectories computed from conventional upper air data. In the second and third studies, the separation of multiple constant level flights made simultaneously and sequentially is described to suggest the order of magnitude of eddy motion encountered by the balloons in flight.

TRAJECTORIES COMPARED WITH FORECASTS

A large number of constant level balloon flights were made by the authors during the summer of 1951. The balloons were normally spheres, 25 feet in diameter, instrumented to float on the 300 mb pressure surface. Launchings were made from Hill Air Force Base, Ogden, Utah, and balloons were tracked by aircraft over constant level trajectories averaging about 1000 miles. Attempts were made to forecast the impact point of the balloons at the end of their flight. The forecasts of trajectories and impacts were made before the balloons were launched to insure complete honesty in the predictions. Such flights were carried out repeatedly using multiple forecasters and standardized procedures to minimize subjectivity. Although it was found that better forecasts could be made under certain selected weather situations and that some proficiency improved the forecasts, the accuracy which could be obtained under the best conditions was limited. Average errors in the prediction of the impact point of about 23% of the total range were experienced under all weather situations for which balloons were flown. Under conditions selected by the forecaster as optimum, this error could not be reduced below 18% of the distance travelled.

It was recognized that operational degradation would reduce the effectiveness of the forecasts whenever the time of launching, rate of rise, floating altitude or flight duration were different from those assumed by the forecaster. In addition, errors in the basic forecast of the pressure and wind fields to be encountered during flight would affect the accuracy of the trajectory forecast. A third cause for failure to make a good trajectory forecast would be the possible falseness of the assumption that the horizontal motion of the balloon is controlled by the air with which it is surrounded.

In an attempt to separate these variables, a study was made of 20 flights selected for good mechanical behavior, i.e. adherence to the 300 mb level and extension of an average length of 1000 miles. An independent forecaster, Dr. Homer Mantis of the University of Minnesota, compared the trajectories of these flights, using "hindcast" trajectories made from the in-flight winds and pressure fields as reported by the U. S. Weather Bureau stations during the flight period. Consideration was given to the exact launching time, ascent vector, floating altitude, and flight duration. For these 20 flights of an average 1000 miles length, the average error in the end point was 20% of the total flight length. This surprisingly large "hindcast" error amounts to about 80% of the original forecast error and strongly suggests that either (1) the balloon held on a constant pressure surface does not move with the horizontal wind at that surface, or (2) the field of motion as it is presently described is far more inadequate than previously believed.

EFFECTS OF EDDY DIFFUSION

If the balloons do not move with the wind at their level, is it because no representative wind exists? It has been postulated that air motion is such a complex of eddies that conceivably a large number of trajectories might be obtained in a single given situation. To test this assumption, simultaneous multiple constant level balloon flights were made. They have been studied by Mantis and Gaalswyk and the pertinent conclusions are quoted below.

"The effects of eddy motion appear in the equations of motion as eddy stresses, and therefore depend on the definition of the average large scale flow. In a sense, conventional synoptic analysis represents a large scale flow which is averaged over the space between the reporting stations. The trajectory of a single balloon, therefore, should consist of a component due to the large scale motion and a component due to the eddy motions. A random distribution of eddy motions would have the effect of diverting a single balloon from the large scale flow or causing the diffusion of a cluster of balloons. The magnitude of this effect is not known; estimates vary by as much as several orders of magnitude. In past experiments on the diffusion of balloon clusters or other tracers, it appears that the effect of eddy motions is frequently obscured by the effect of the vertical shear on the motion of tracing elements at slightly different altitudes.

"The results of a limited number of simultaneous multiple constant level balloons made by General Mills therefore offer unique opportunities for the examination of the diffusion effects. On three occasions, it is possible to isolate the effects of eddy diffusion by multiple flights in which a minimum difference in balloon altitude was maintained during the flights. In the flights 557-558, 566-567-568, and 561-562, the maintenance of altitude was within $\pm$ 150 ft. ($\pm$ 2 mb) of the desired control altitude for each balloon. The only exception occurred on flight 566 which was off by 300 feet for a short time. The results of these flights are given in the following table:

Flights compared	Distance of flight under comparison Miles	Duration of flt. under comparison Hrs.	Distance balloons were apart Mi.	Balloon separation as % of distance %	Across-track variation of trajectory
557-558	750	14.5	11	1.3	
561-562	1000	18.0	14	1.8	
566-567	1200	20.2	1	.08	1
566-567	1200	20.2	5	.4	1
567-568	1200	20.2	5	.4	1

"The consistence of these results seems to definitely establish the order of magnitude of the effect of eddy diffusion. This effect is certainly negligible as a factor in the accuracy of trajectory construction."

A few other multiple flights have been made where the balloons have been separated in time or altitude. Flights 564-565 travelled 1640 miles in 27.2 hours, one at an average altitude of 32,000, the other at 29,500. At the termination of the flight, the balloons were 18 miles apart with a cross track separation of the trajectories of only 7 miles.

Flights 576-577 were launched 51 minutes apart. Flight 576 floated at an average altitude of 30,500; flight 577 floated at about 31,000 ft. At the end of 31 hours, the balloons had travelled about 1200 miles and were 44 miles apart with a 17 mile separation between their trajectories (apparently due to change of the pressure field).

Similar experiments were made to show the effect of separating trajectories in time. In each case, a regular progression of the trajectories was observed and a general adherence to the synoptic track as reported by standard observations was noted, although the balloon trajectories could not be predicted persistently nor made to conform rigorously to the computed in-flight trajectories.

From this study, one may conclude that a representative trajectory of some sort can be obtained by constant level balloons. If this is truly the large-scale air motion which is represented, the instantaneous field of motion in the upper air is being misrepresented by 20% with present observation techniques.

PILLOW BALLOONS

In other efforts to trace air parcels inexpensively, small constant volume balloons were devised at General Mills. These balloons, because of their square shape arising from their construction, have been labelled 'pillow balloons'. Many mass flights of these balloons have been made in which 50 or more balloons were launched simultaneously. It appears that these balloons do not maintain a long constant level flight, except under special operating conditions. The recoveries of these balloons show that they fall out along a line which frequently has been no wider than ten miles for a mean range of 600 miles. The data on these flights are also given in the attached exhibits.

Two such inexpensive, uninstrumented balloons launched from Minneapolis, have been returned from Ireland, illustrating the trajectory tracing potential possible for inexpensive constant volume balloons.

CONCLUSION

From the controlled altitude flights, and the pillow balloon data given in the exhibits, it appears that a meaningful and representative measurement of horizontal wind velocities might be made using a constant level balloon principle. From the repeatability of the wind measurements made from trajectory balloons, it appears that the small scale variability of the wind may give non-representative values for short term wind observations. The use of a small, inexpensive, constant-level balloon on standard surfaces to complement wind measurements by sounding balloons should integrate out the variability of effects and permit better delineation of the flow of the air.

To use these constant level balloons meaningfully, it will be necessary to determine the minimum constant level flight duration feasible which will smooth out the effects of superimposed eddy motion and to permit the direct observation of a wind good enough for determinations of atmospheric accelerations as well as the representative air velocity. This problem has been considered by Durst, Machta and Mantis and some definitive experiments are being planned. It appears, however, that 30 minute observations of the displacement of a constant level balloon will yield a much more representative wind measurement than the present two-minute, sounding balloon observations.

Direct observation of balloon trajectories should be a valuable forecast tool, particularly for tropical meteorology. By this method, fields of divergence or convergence might be directly observed and studied rather than inferred by the existing weather and measurement of the pressure gradients in those latitudes.

The tracking of constant level balloons to obtain air trajectories at great ranges from otherwise inaccessible areas may be another use and extension of this technique for meteorological problems. Such a use is being contemplated by the Naval Research Laboratory in the transosonde project to obtain wind and trajectory data from over the Central Pacific.

Consideration should also be given to the direct observation of trajectories as a routine weather observation tool complementing existing techniques.

DEFINITIVE EXPERIMENTS WHICH ARE NEEDED

1. Repeated, simultaneous observations of the variability of the wind, made by launching small meteorological constant level balloons at intervals, comparing the wind attained for each two minute period with an average from a 30 minute displacement. These data should in turn be compared with:

   a. synoptic rawin soundings,

   b. the constant level wind measured by similar units located across wind at distances of 1, 10, and perhaps 100 miles,

   c. the wind measured by the same stations on any constant level balloons 30 and 60 minutes later.

2. Nationwide wind observations on a standard surface by one hour flights of small constant level balloons from the U. S. Weather Bureau rawin stations synoptic with the standard rawin soundings.

3. Establishment of a tracking net for larger constant level balloons in the tropics and the making of simultaneous flights to observe directly the atmospheric convergence and divergence particularly around hurricane time.

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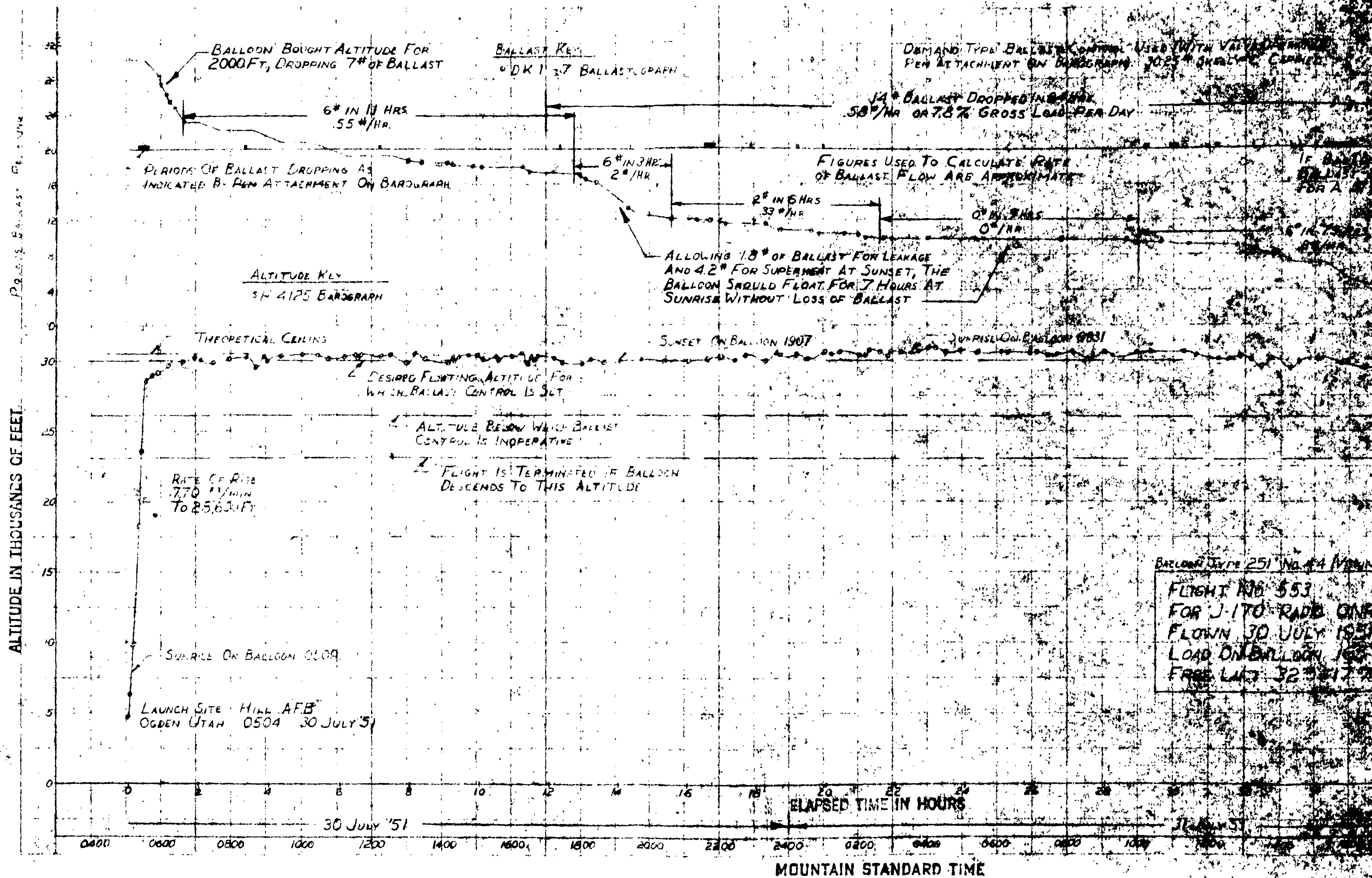
Four twenty-five foot diameter balloons being inflated for a simultaneous launching. These balloons carrying a 160 pound payload, will float on the 300 millibar surface where they will be used to study atmospheric divergence.



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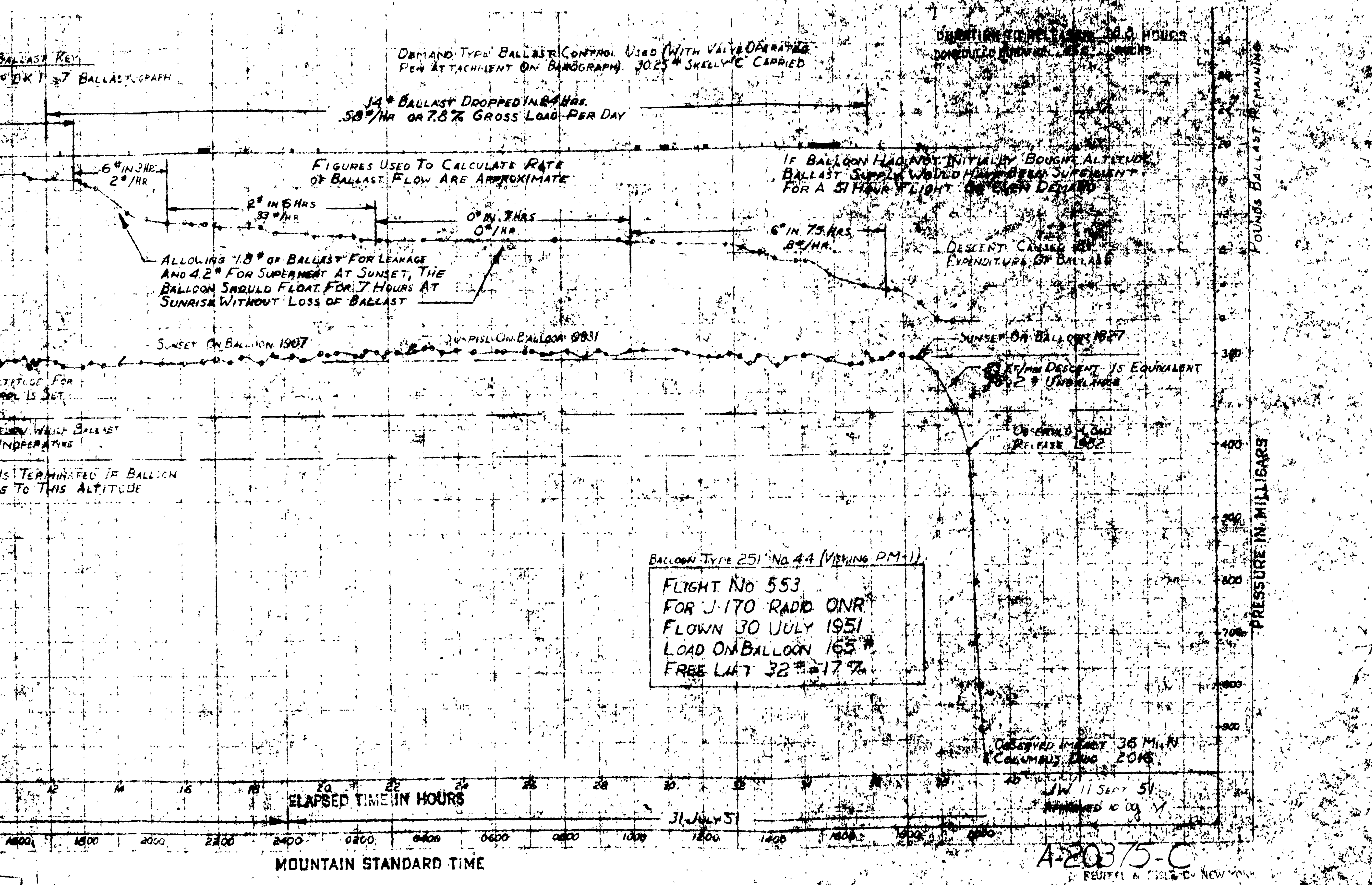

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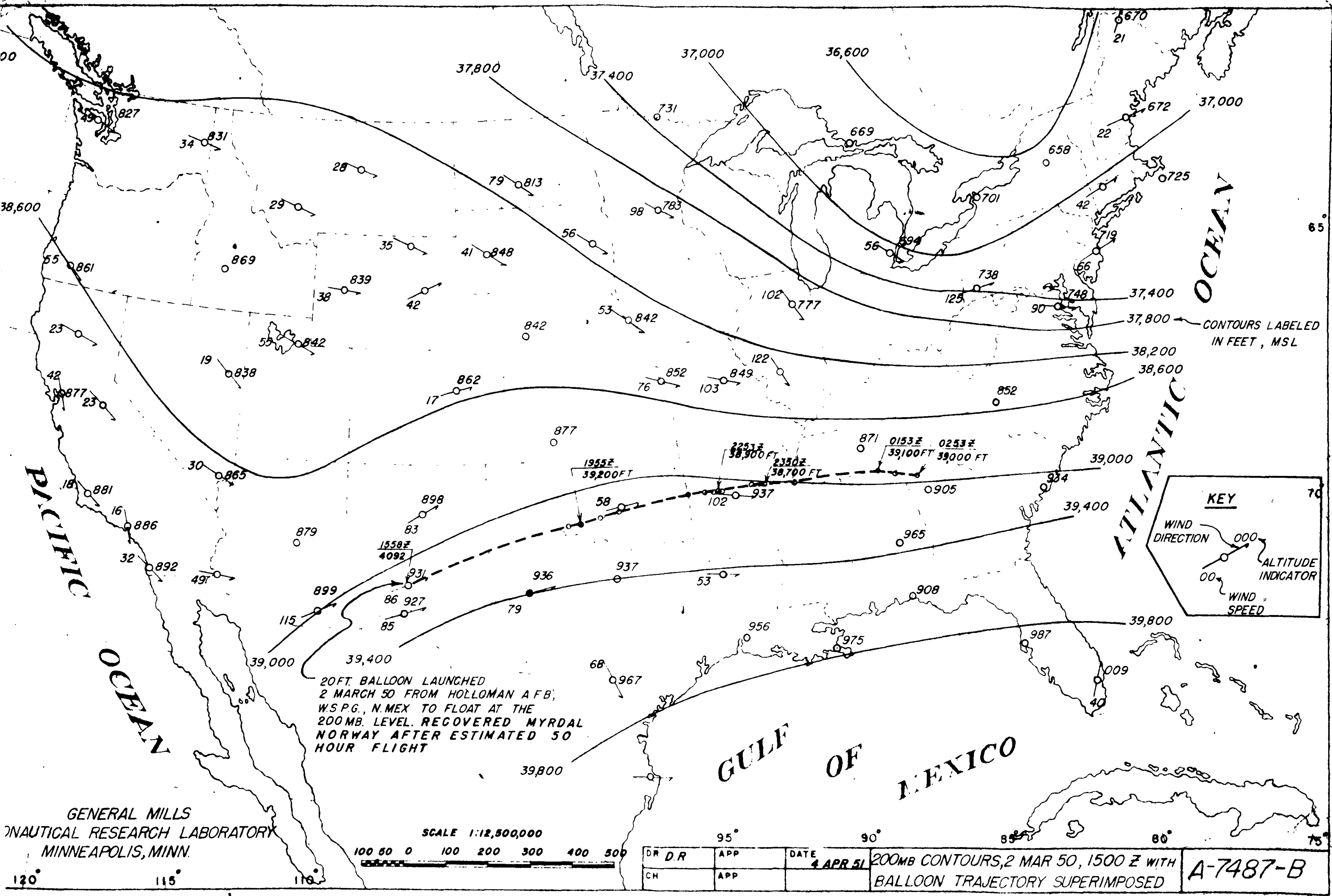
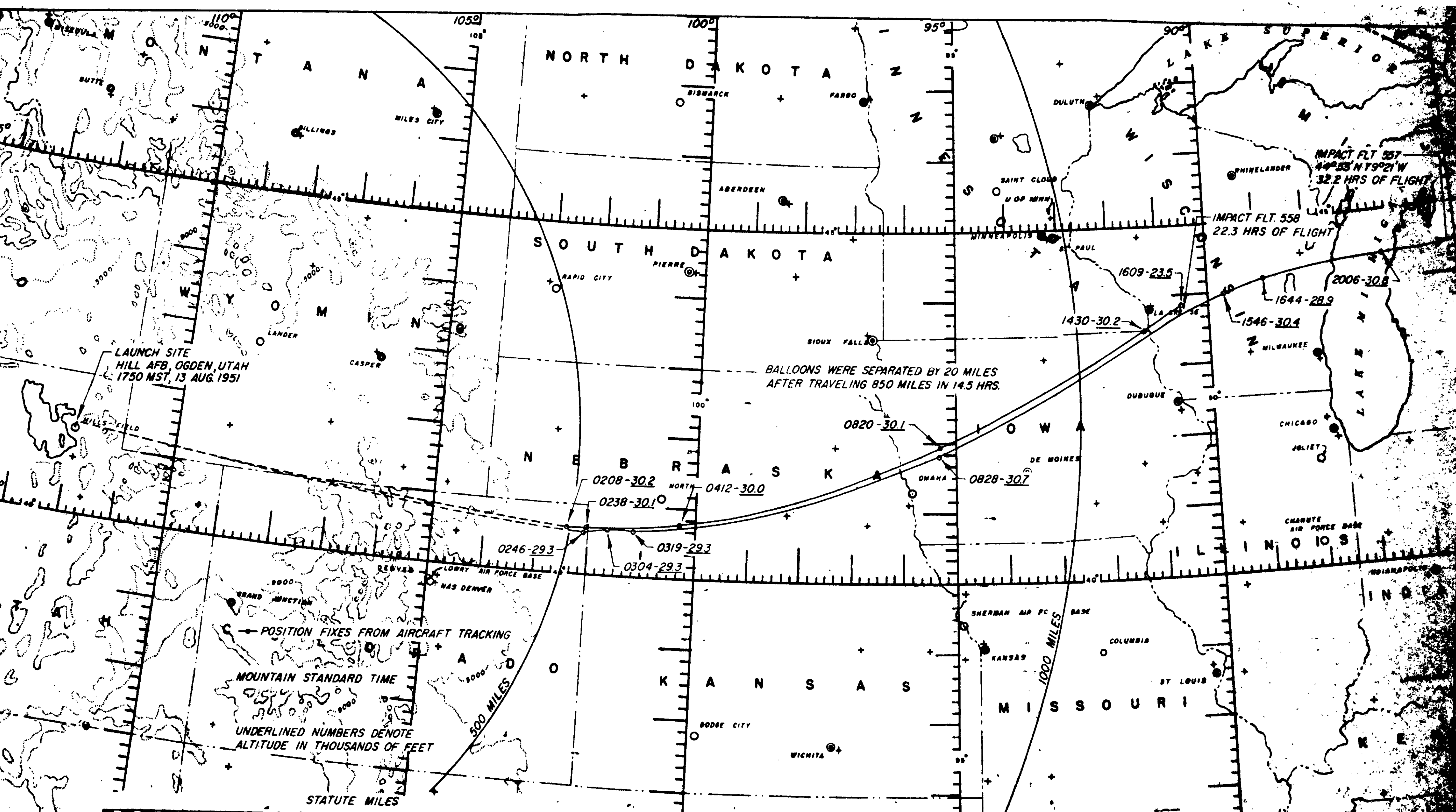


PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
CONTOURS LABELED IN FEET, MSL
KEY
WIND DIRECTION
ALTITUDE INDICATOR
WIND SPEED
36,600
37,000
37,400
37,800
38,200
38,600
39,000
39,400
39,800
1558Z 4092
1955Z 39,200 FT
2251Z 38,900 FT
2350Z 38,700 FT
0153Z 39,100 FT
0253Z 39,000 FT
20 FT. BALLOON LAUNCHED 2 MARCH 50 FROM HOLLOMAN A.F.B, W.S.P.G., N.MEX TO FLOAT AT THE 200 MB. LEVEL. RECOVERED MYRDAL NORWAY AFTER ESTIMATED 50 HOUR FLIGHT
SCALE 1:12,500,000
100 50 0 100 200 300 400 500
GENERAL MILLS
AERONAUTICAL RESEARCH LABORATORY
MINNEAPOLIS, MINN.
DR D.R
CH
APP
APP
DATE 4 APR 51
200MB CONTOURS, 2 MAR 50, 1500 Z WITH BALLOON TRAJECTORY SUPERIMPOSED
A-7487-B

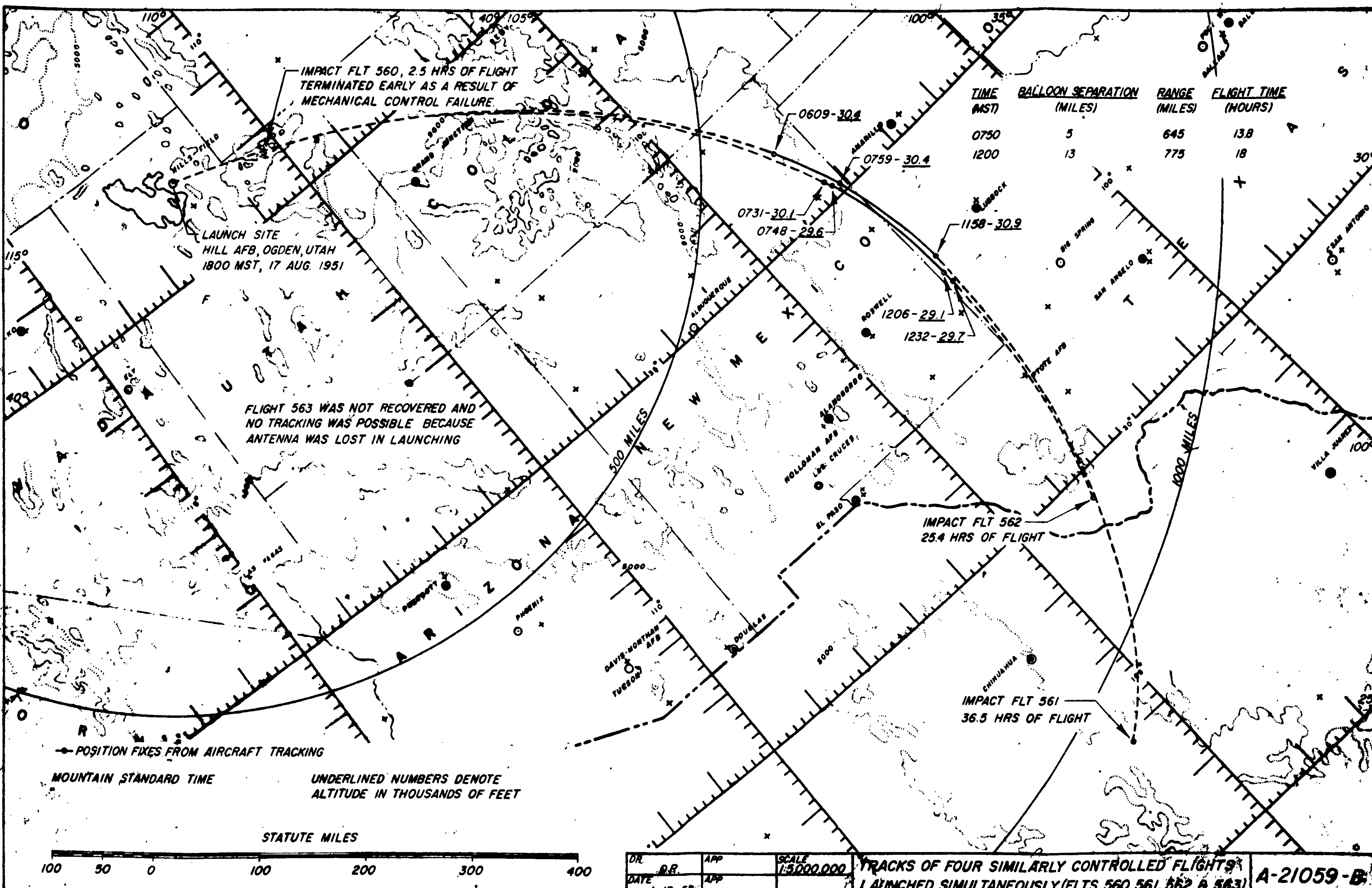
DATA ON CONTROLLED
ALTITUDE FLIGHTS



DR	DR	APP	SCALE 1:5,000,000	TRACKS FOR TWO SIMILARLY CONTROLLED FLIGHTS LAUNCHED SIMULTANEOUSLY (FLTS. 557 & 558)	A-21068-C
DATE	1-12-53	APP			

GENERAL MILLS AERONAUTICAL RESEARCH LABORATORY, MINNEAPOLIS, MINNESOTA

JAN 21 1953



TIME (MST)	BALLOON SEPARATION (MILES)	RANGE (MILES)	FLIGHT TIME (HOURS)
0750	5	645	13.8
1200	13	775	18

DR. D.R.	APP	SCALE 1:5,000,000	TRACKS OF FOUR SIMILARLY CONTROLLED FLIGHTS LAUNCHED SIMULTANEOUSLY (FLTS. 560, 561, 562 & 563)
DATE 1-13-53	APP		A-21059-B

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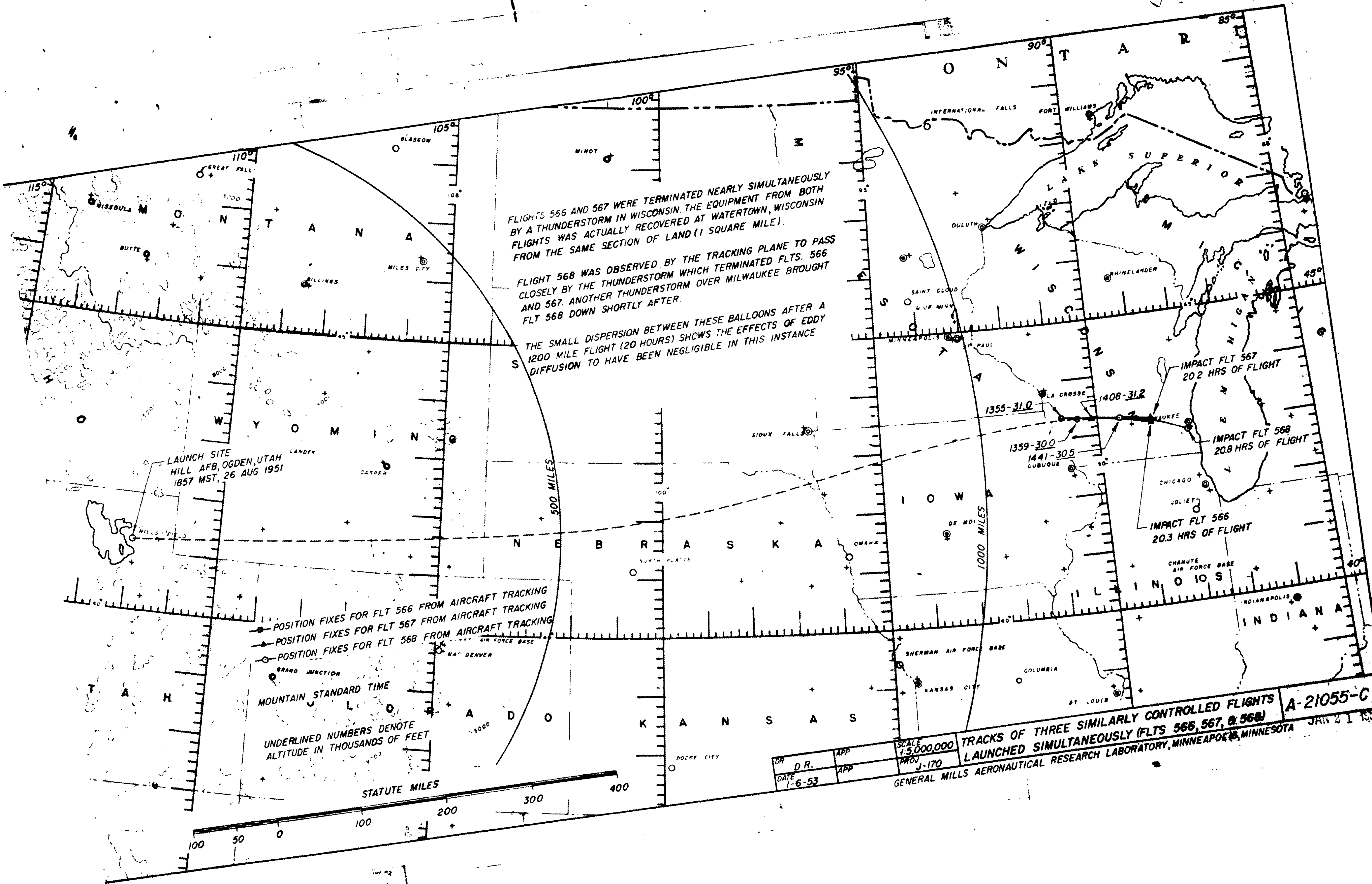
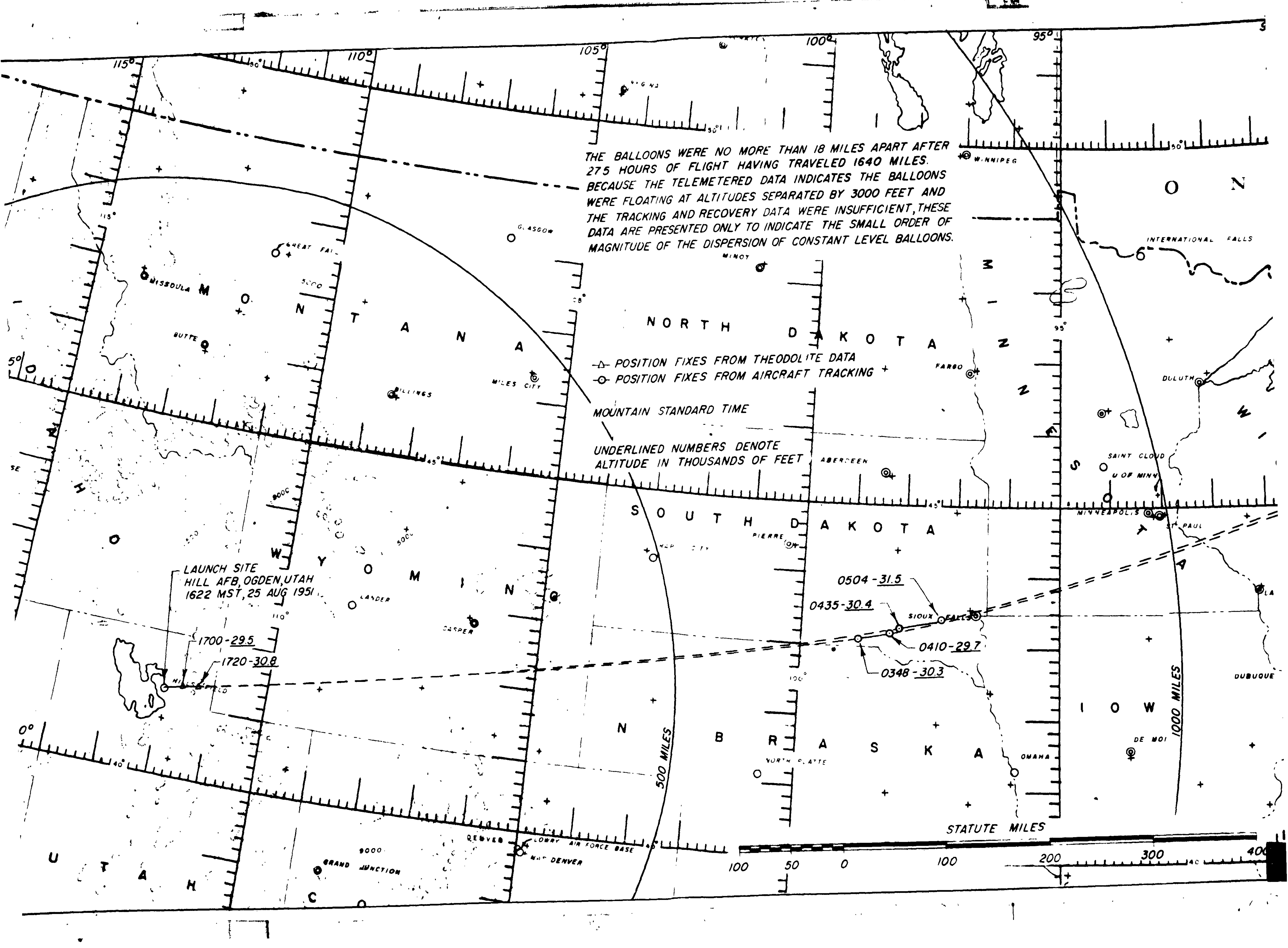
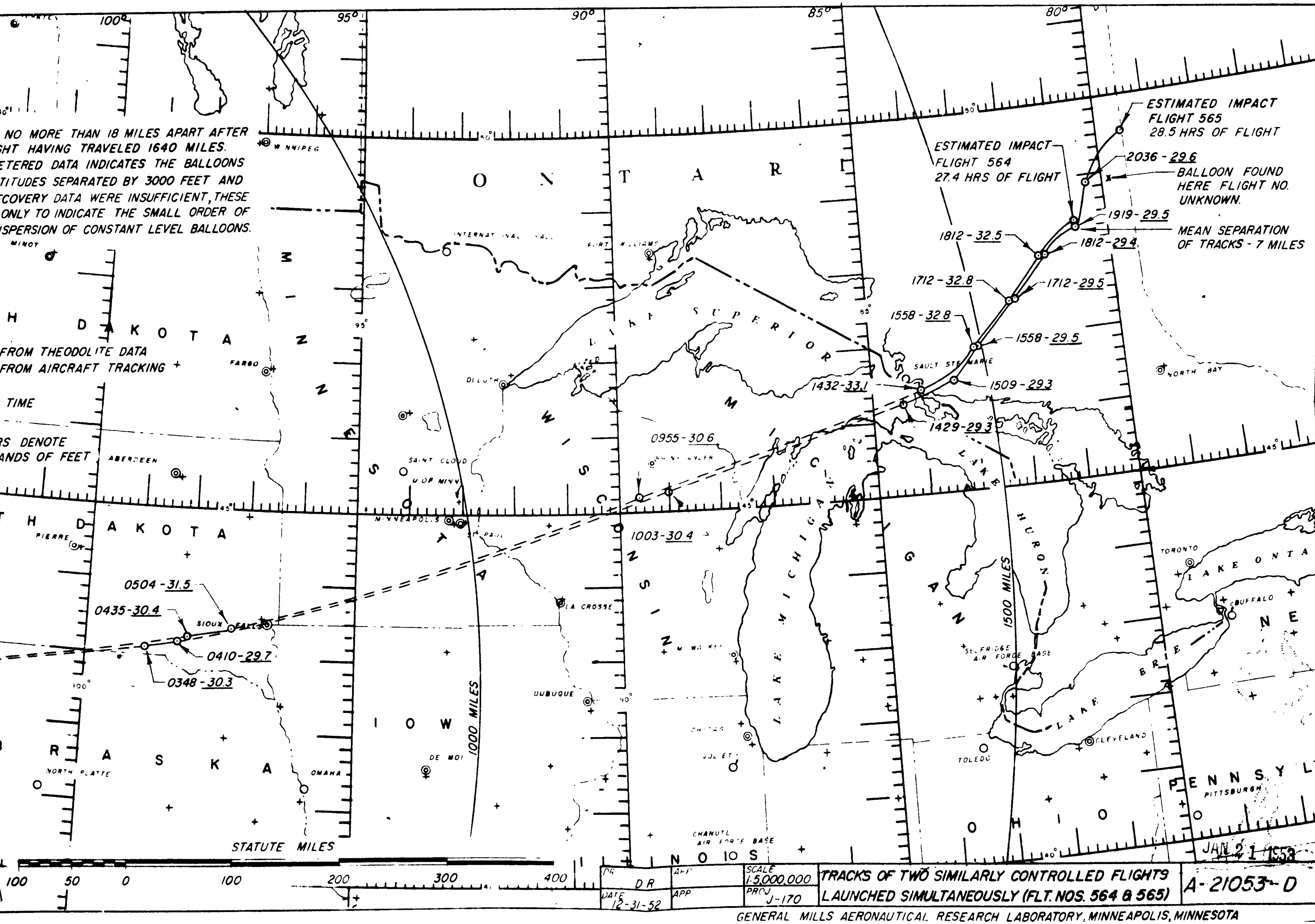
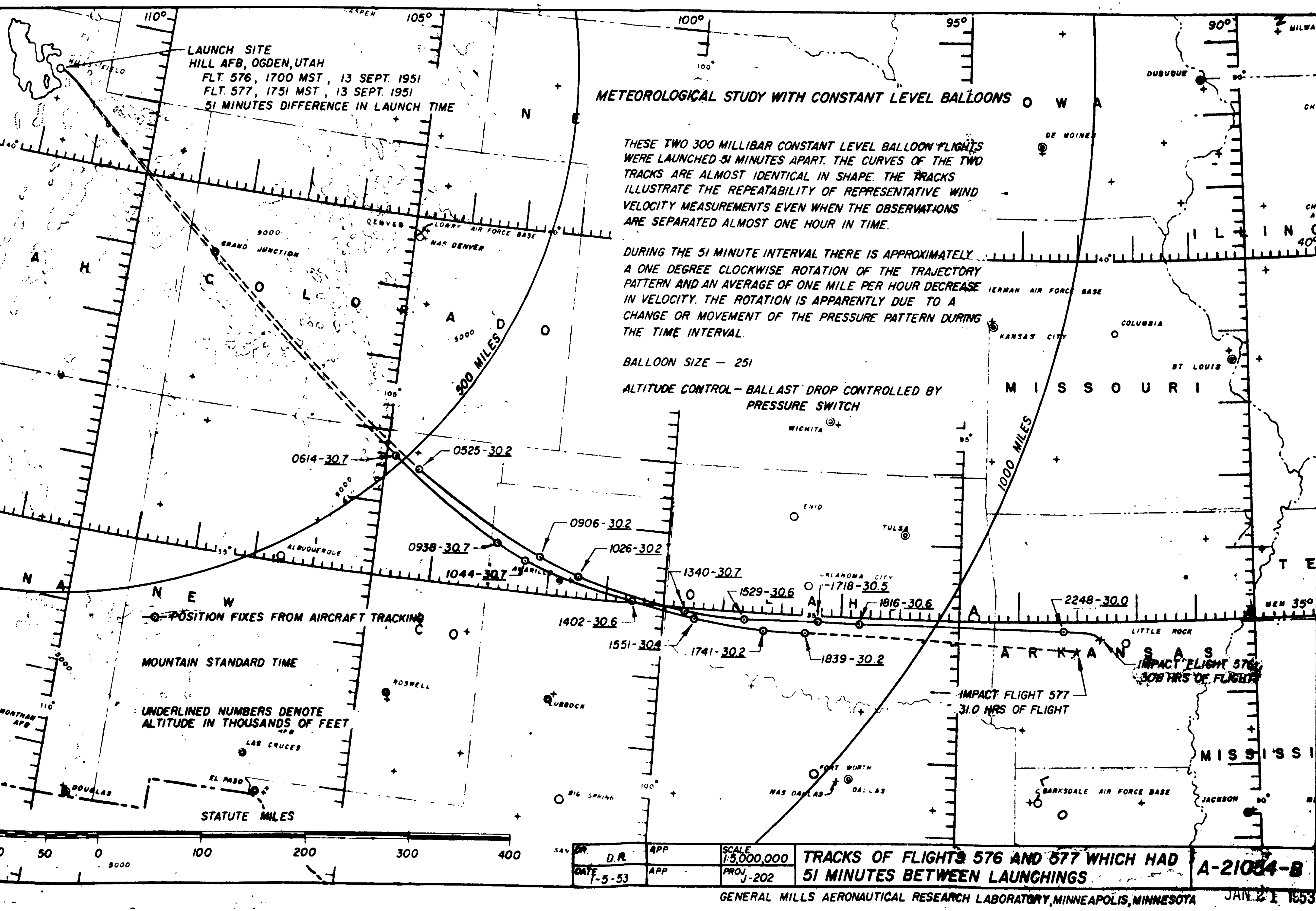
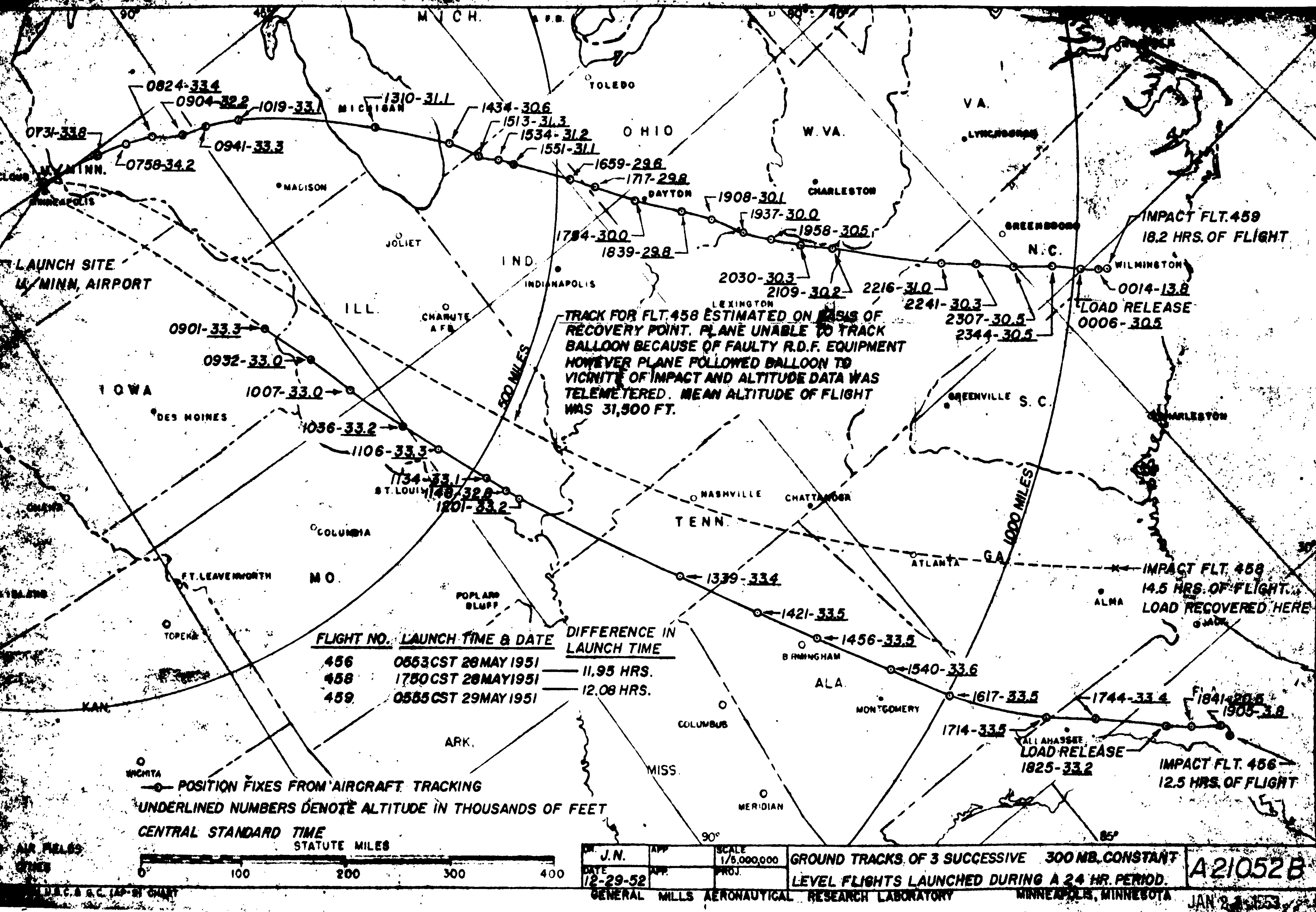
JAN 21 1953

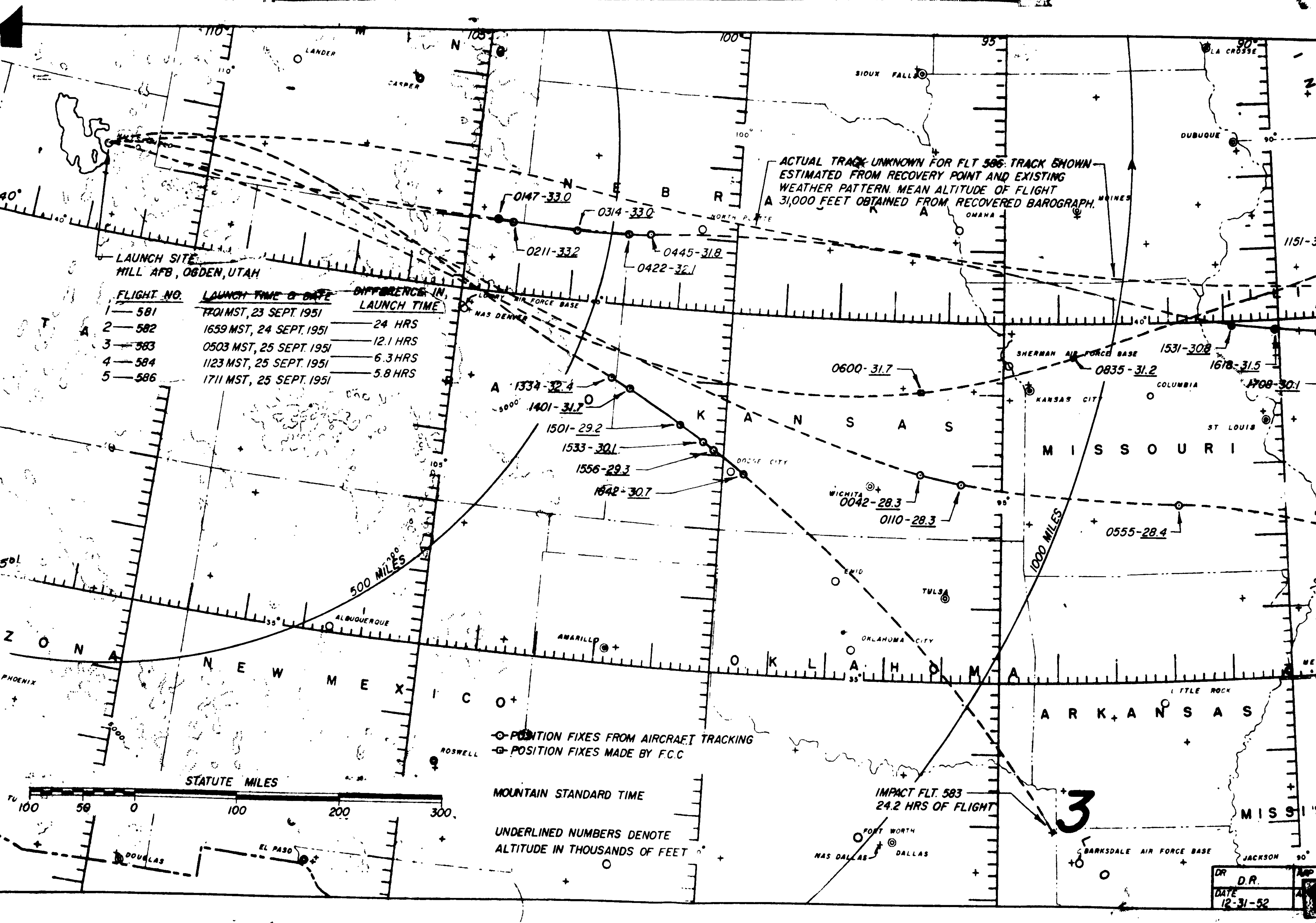

FLIGHTS 566 AND 567 WERE TERMINATED NEARLY SIMULTANEOUSLY BY A THUNDERSTORM IN WISCONSIN. THE EQUIPMENT FROM BOTH FLIGHTS WAS ACTUALLY RECOVERED AT WATERTOWN, WISCONSIN FROM THE SAME SECTION OF LAND (1 SQUARE MILE).
FLIGHT 568 WAS OBSERVED BY THE TRACKING PLANE TO PASS CLOSELY BY THE THUNDERSTORM WHICH TERMINATED FLTS. 566 AND 567. ANOTHER THUNDERSTORM OVER MILWAUKEE BROUGHT FLT 568 DOWN SHORTLY AFTER.
THE SMALL DISPERSION BETWEEN THESE BALLOONS AFTER A 1200 MILE FLIGHT (20 HOURS) SHOWS THE EFFECTS OF EDDY DIFFUSION TO HAVE BEEN NEGLIGIBLE IN THIS INSTANCE
LAUNCH SITE
HILL AFB, OGDEN, UTAH
1857 MST, 26 AUG 1951
IMPACT FLT 567
20.2 HRS OF FLIGHT
IMPACT FLT 568
20.8 HRS OF FLIGHT
IMPACT FLT 566
20.3 HRS OF FLIGHT
1355-31.0
1408-31.2
1359-30.0
1441-30.5
500 MILES
1000 MILES
POSITION FIXES FOR FLT 566 FROM AIRCRAFT TRACKING
POSITION FIXES FOR FLT 567 FROM AIRCRAFT TRACKING
POSITION FIXES FOR FLT 568 FROM AIRCRAFT TRACKING
MOUNTAIN STANDARD TIME
UNDERLINED NUMBERS DENOTE ALTITUDE IN THOUSANDS OF FEET
STATUTE MILES
100 50 0 100 200 300 400
ONTARIO
LAKE SUPERIOR
MONTANA
WYOMING
NEBRASKA
KANSAS
COLORADO
UTAH
IDAHO
IOWA
MINNESOTA
WISCONSIN
MICHIGAN
LAKE MICHIGAN
ILLINOIS
INDIANA
INTERNATIONAL FALLS
FORT WILLIAMS
DULUTH
RHINELANDER
SAINT CLOUD
MINNEAPOLIS
ST PAUL
LA CROSSE
DUBUQUE
CHICAGO
JOLIET
CHANUTE AIR FORCE BASE
INDIANAPOLIS
ST LOUIS
COLUMBIA
KANSAS CITY
SHERMAN AIR FORCE BASE
DE MOINES
OMAHA
SIOUX FALLS
NORTH PLATTE
DODGE CITY
MINOT
GLASGOW
GREAT FALLS
MISSOULA
BUTTE
BILLINGS
MILES CITY
CASPER
LANDER
DENVER
GRAND JUNCTION
115° 110° 105° 100° 95° 90° 85°
45° 40°
TRACKS OF THREE SIMILARLY CONTROLLED FLIGHTS LAUNCHED SIMULTANEOUSLY (FLTS 566, 567, & 568)
GENERAL MILLS AERONAUTICAL RESEARCH LABORATORY, MINNEAPOLIS, MINNESOTA
DR D.R.
DATE 1-6-53
APP
APP
SCALE 1:5,000,000
PROJ J-170
A-21055-C
JAN 21 1953


THE BALLOONS WERE NO MORE THAN 18 MILES APART AFTER 275 HOURS OF FLIGHT HAVING TRAVELED 1640 MILES. BECAUSE THE TELEMETERED DATA INDICATES THE BALLOONS WERE FLOATING AT ALTITUDES SEPARATED BY 3000 FEET AND THE TRACKING AND RECOVERY DATA WERE INSUFFICIENT, THESE DATA ARE PRESENTED ONLY TO INDICATE THE SMALL ORDER OF MAGNITUDE OF THE DISPERSION OF CONSTANT LEVEL BALLOONS.
POSITION FIXES FROM THEODOLITE DATA
POSITION FIXES FROM AIRCRAFT TRACKING
MOUNTAIN STANDARD TIME
UNDERLINED NUMBERS DENOTE ALTITUDE IN THOUSANDS OF FEET
LAUNCH SITE
HILL AFB, OGDEN, UTAH
1622 MST, 25 AUG 1951
1700-29.5
1720-30.8
0348-30.3
0410-29.7
0435-30.4
0504-31.5
500 MILES
1000 MILES
STATUTE MILES
100 50 0 100 200 300 400
MONTANA
NORTH DAKOTA
SOUTH DAKOTA
WYOMING
NEBRASKA
MINNESOTA
IOWA
UTAH
GLASGOW
GREAT FALLS
MISSOULA
BUTTE
BILLINGS
MILES CITY
MINOT
FARGO
ABERDEEN
PIERRE
CASPER
LANDER
DENVER
LOWRY AIR FORCE BASE
GRAND JUNCTION
NORTH PLATTE
OMAHA
SIOUX FALLS
MINNEAPOLIS
ST. PAUL
SAINT CLOUD
U OF MINN
DULUTH
INTERNATIONAL FALLS
WINNIPEG
DUBUQUE
DE MOI
115°
110°
105°
100°
95°

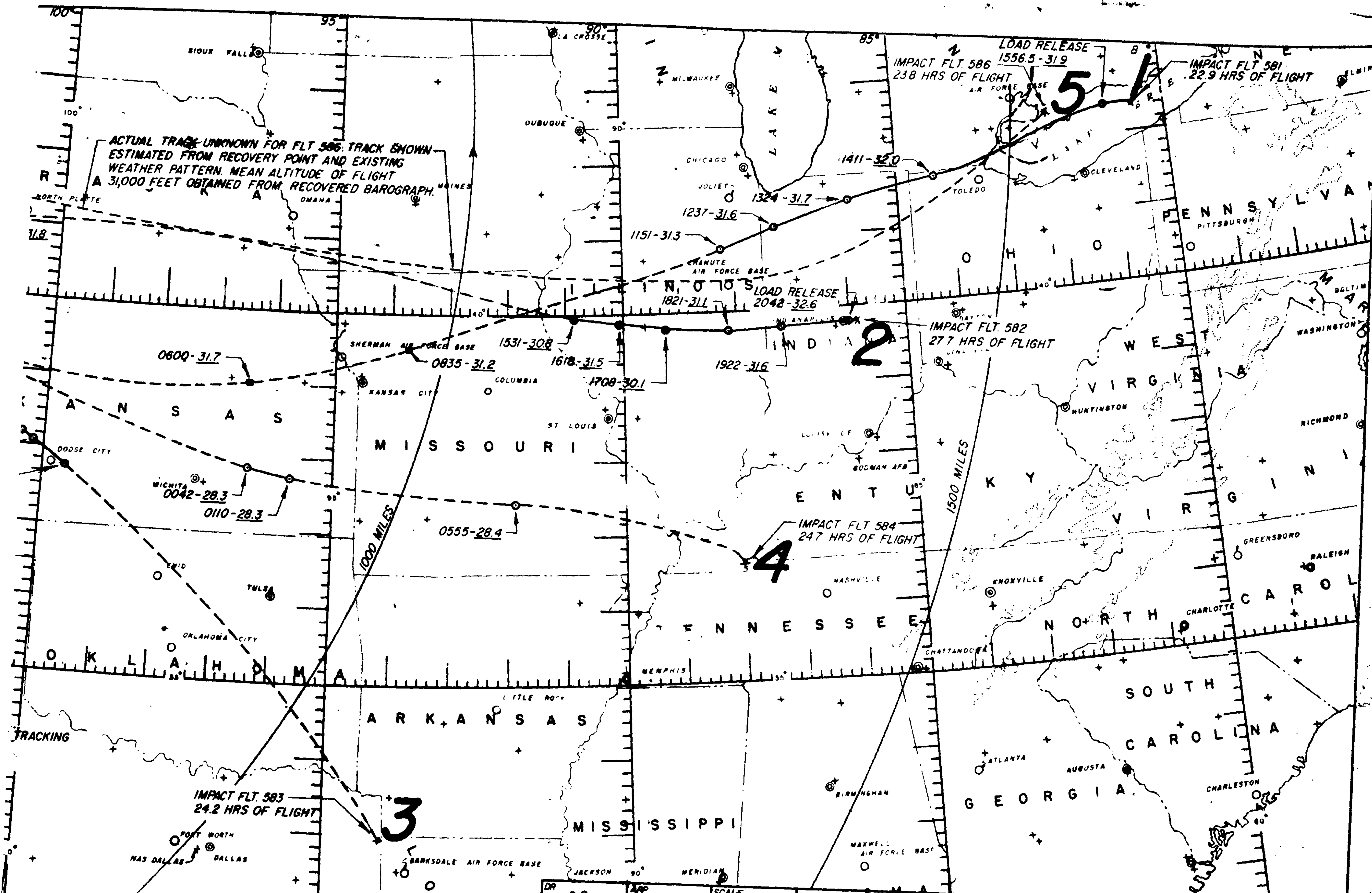

ESTIMATED IMPACT FLIGHT 565 28.5 HRS OF FLIGHT
2036 - 29.6
BALLOON FOUND HERE FLIGHT NO. UNKNOWN.
1919 - 29.5
MEAN SEPARATION OF TRACKS - 7 MILES
ESTIMATED IMPACT FLIGHT 564 27.4 HRS OF FLIGHT
1812 - 32.5
1812 - 29.4
1712 - 32.8
1712 - 29.5
1558 - 32.8
1558 - 29.5
1509 - 29.3
1432 - 33.1
1429 - 29.3
0955 - 30.6
1003 - 30.4
0504 - 31.5
0435 - 30.4
0410 - 29.7
0348 - 30.3
1000 MILES
1500 MILES
NO MORE THAN 18 MILES APART AFTER
GHT HAVING TRAVELED 1640 MILES.
ETERED DATA INDICATES THE BALLOONS
TITUDES SEPARATED BY 3000 FEET AND
COVERY DATA WERE INSUFFICIENT, THESE
ONLY TO INDICATE THE SMALL ORDER OF
SPERSION OF CONSTANT LEVEL BALLOONS.
FROM THEODOLITE DATA
FROM AIRCRAFT TRACKING +
TIME
RS DENOTE
ANDS OF FEET
ONTARIO
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ERIE
LAKE ONTARIO
MINNESOTA
WISCONSIN
MICHIGAN
IOWA
ILLINOIS
OHIO
PENNSYL
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
NE
WINNIPEG
FORT WILLIAMS
DULUTH
SAULT STE MARIE
NORTH BAY
TORONTO
BUFFALO
PITTSBURGH
CLEVELAND
TOLEDO
SELFRIDGE AIR FORCE BASE
CHANUTE AIR FORCE BASE
MINNEAPOLIS
ST PAUL
SAINT CLOUD
U OF MINN
LA CROSSE
DUBUQUE
DE MOI
OMAHA
SIOUX FALLS
FARGO
ABERDEEN
PIERRE
NORTH PLATTE
MINOT
CHICAGO
JOLIET
INTERNATIONAL FALLS
95°
90°
85°
80°
100°
45°
50°
STATUTE MILES
100 50 0 100 200 300 400
DR
D R
APP
DATE 12-31-52
SCALE 1:5,000,000
PROJ J-170
TRACKS OF TWO SIMILARLY CONTROLLED FLIGHTS
LAUNCHED SIMULTANEOUSLY (FLT. NOS. 564 & 565)
A-21053-D
JAN 21 1953
GENERAL MILLS AERONAUTICAL RESEARCH LABORATORY, MINNEAPOLIS, MINNESOTA


METEOROLOGICAL STUDY WITH CONSTANT LEVEL BALLOONS
THESE TWO 300 MILLIBAR CONSTANT LEVEL BALLOON FLIGHTS WERE LAUNCHED 51 MINUTES APART. THE CURVES OF THE TWO TRACKS ARE ALMOST IDENTICAL IN SHAPE. THE TRACKS ILLUSTRATE THE REPEATABILITY OF REPRESENTATIVE WIND VELOCITY MEASUREMENTS EVEN WHEN THE OBSERVATIONS ARE SEPARATED ALMOST ONE HOUR IN TIME.
DURING THE 51 MINUTE INTERVAL THERE IS APPROXIMATELY A ONE DEGREE CLOCKWISE ROTATION OF THE TRAJECTORY PATTERN AND AN AVERAGE OF ONE MILE PER HOUR DECREASE IN VELOCITY. THE ROTATION IS APPARENTLY DUE TO A CHANGE OR MOVEMENT OF THE PRESSURE PATTERN DURING THE TIME INTERVAL.
BALLOON SIZE — 251
ALTITUDE CONTROL — BALLAST DROP CONTROLLED BY PRESSURE SWITCH
LAUNCH SITE
HILL AFB, OGDEN, UTAH
FLT. 576, 1700 MST, 13 SEPT. 1951
FLT. 577, 1751 MST, 13 SEPT. 1951
51 MINUTES DIFFERENCE IN LAUNCH TIME
0525-30.2
0614-30.7
0906-30.2
0938-30.7
1026-30.2
1044-30.7
1340-30.7
1402-30.6
1529-30.6
1551-30.4
1718-30.5
1741-30.2
1816-30.6
1839-30.2
2248-30.0
IMPACT FLIGHT 576
30.8 HRS OF FLIGHT
IMPACT FLIGHT 577
31.0 HRS OF FLIGHT
500 MILES
1000 MILES
POSITION FIXES FROM AIRCRAFT TRACKING
MOUNTAIN STANDARD TIME
UNDERLINED NUMBERS DENOTE ALTITUDE IN THOUSANDS OF FEET
STATUTE MILES
50
0
100
200
300
400
110°
105°
100°
95°
90°
40°
35°
COLORADO
NEW MEXICO
MISSOURI
IOWA
ARKANSAS
DUBUQUE
DE MOINES
KANSAS CITY
COLUMBIA
ST LOUIS
WICHITA
ENID
TULSA
OKLAHOMA CITY
LITTLE ROCK
AMARILLO
ALBUQUERQUE
ROSWELL
LUBBOCK
LAS CRUCES
EL PASO
DOUGLAS
BIG SPRING
FORT WORTH
DALLAS
NAS DALLAS
BARKSDALE AIR FORCE BASE
JACKSON
GRAND JUNCTION
DENVER
LOWRY AIR FORCE BASE
NAS DENVER
DR. D.R.
DATE 1-5-53
APP
APP
SCALE 1:5,000,000
PROJ J-202
TRACKS OF FLIGHTS 576 AND 577 WHICH HAD 51 MINUTES BETWEEN LAUNCHINGS
A-21084-B
GENERAL MILLS AERONAUTICAL RESEARCH LABORATORY, MINNEAPOLIS, MINNESOTA
JAN 21 1953


MICH.
OHIO
W. VA.
VA.
IND.
ILL.
IOWA
MO.
TENN.
KAN.
ARK.
MISS.
ALA.
GA.
S. C.
N. C.
FLA.
MINN.
TOLEDO
MADISON
JOLIET
INDIANAPOLIS
CHARUTE AFB
DES MOINES
DAYTON
CHARLESTON
LEXINGTON
GREENSBORO
WILMINGTON
GREENVILLE
CHARLESTON
NASHVILLE
CHATTANOOGA
ATLANTA
ALMA
ST. LOUIS
COLUMBIA
FT. LEAVENWORTH
TOPEKA
WICHITA
POPLAR BLUFF
BIRMINGHAM
MONTGOMERY
COLUMBUS
MERIDIAN
TALLAHASSEE
500 MILES
1000 MILES
0731-33.8
0758-34.2
0824-33.4
0904-32.2
0941-33.3
1019-33.1
1310-31.1
1434-30.6
1513-31.3
1534-31.2
1551-31.1
1659-29.6
1717-29.8
1754-30.0
1839-29.8
1908-30.1
1937-30.0
1958-30.5
2030-30.3
2109-30.2
2216-31.0
2241-30.3
2307-30.5
2344-30.5
0014-13.8
LOAD RELEASE
0006-30.5
IMPACT FLT. 459
18.2 HRS. OF FLIGHT
LAUNCH SITE
U/MINN. AIRPORT
0901-33.3
0932-33.0
1007-33.0
1036-33.2
1106-33.3
1134-33.1
1148-32.8
1201-33.2
1339-33.4
1421-33.5
1456-33.5
1540-33.6
1617-33.5
1714-33.5
1744-33.4
1841-20.5
1905-3.8
LOAD RELEASE
1825-33.2
IMPACT FLT. 456
12.5 HRS. OF FLIGHT
IMPACT FLT. 458
14.5 HRS. OF FLIGHT
LOAD RECOVERED HERE
TRACK FOR FLT. 458 ESTIMATED ON BASIS OF RECOVERY POINT. PLANE UNABLE TO TRACK BALLOON BECAUSE OF FAULTY R.D.F. EQUIPMENT HOWEVER PLANE FOLLOWED BALLOON TO VICINITY OF IMPACT AND ALTITUDE DATA WAS TELEMETERED. MEAN ALTITUDE OF FLIGHT WAS 31,500 FT.
FLIGHT NO. | LAUNCH TIME & DATE | DIFFERENCE IN LAUNCH TIME
456 | 0553 CST 28 MAY 1951
458 | 1750 CST 28 MAY 1951 | 11.95 HRS.
459 | 0555 CST 29 MAY 1951 | 12.08 HRS.
POSITION FIXES FROM AIRCRAFT TRACKING
UNDERLINED NUMBERS DENOTE ALTITUDE IN THOUSANDS OF FEET
CENTRAL STANDARD TIME
STATUTE MILES
0
100
200
300
400
90°
85°
DR. J.N.
DATE 12-29-52
APP.
SCALE 1/5,000,000
PROJ.
GROUND TRACKS OF 3 SUCCESSIVE 300 MB. CONSTANT LEVEL FLIGHTS LAUNCHED DURING A 24 HR. PERIOD.
A21052B
GENERAL MILLS AERONAUTICAL RESEARCH LABORATORY MINNEAPOLIS, MINNESOTA
JAN 2 1953



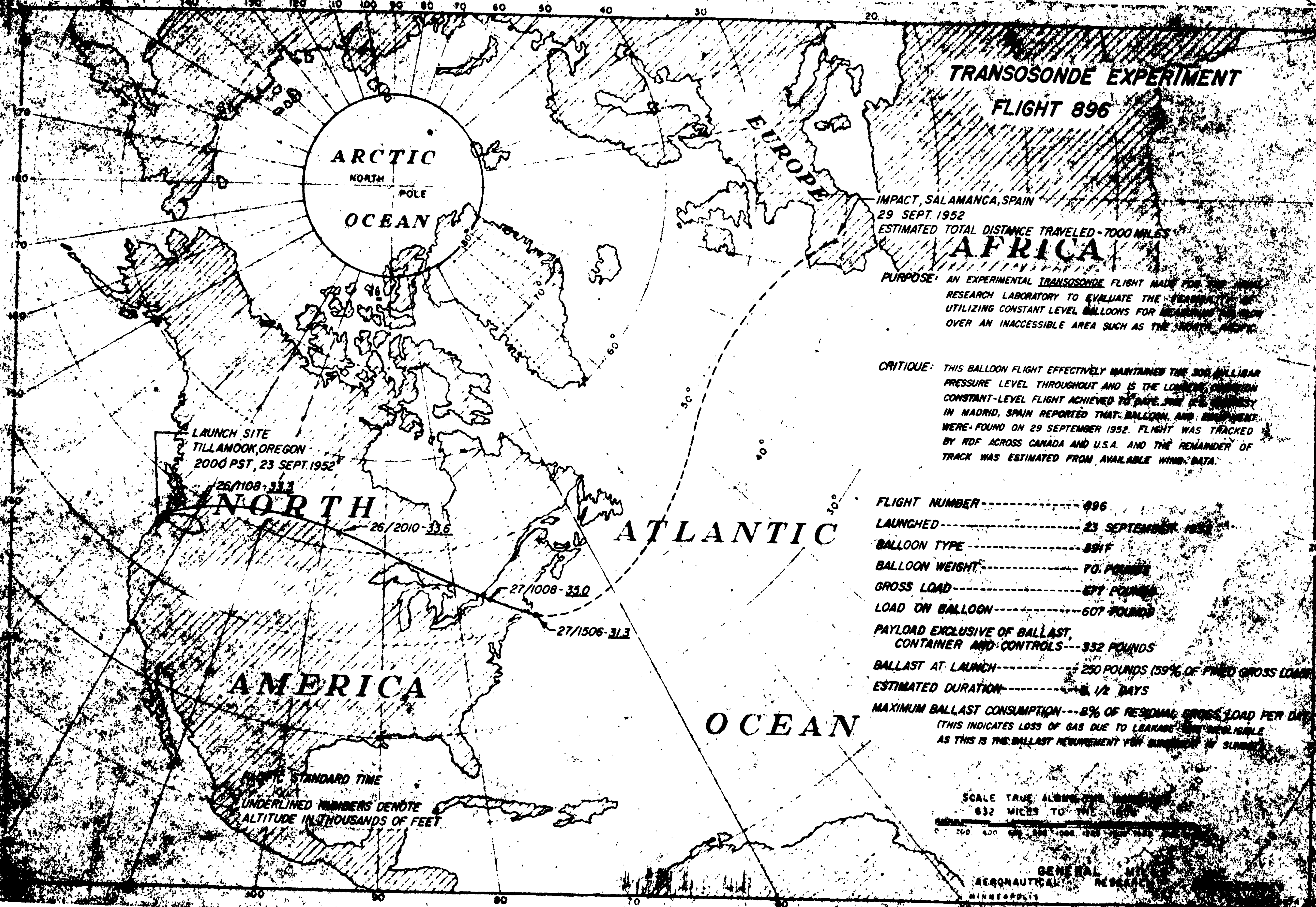
LAUNCH SITE
HILL AFB, OGDEN, UTAH
FLIGHT NO. | LAUNCH TIME & DATE | DIFFERENCE IN LAUNCH TIME
1 — 581 | 1701 MST, 23 SEPT. 1951 |
2 — 582 | 1659 MST, 24 SEPT. 1951 | 24 HRS
3 — 583 | 0503 MST, 25 SEPT. 1951 | 12.1 HRS
4 — 584 | 1123 MST, 25 SEPT. 1951 | 6.3 HRS
5 — 586 | 1711 MST, 25 SEPT. 1951 | 5.8 HRS
ACTUAL TRACK UNKNOWN FOR FLT 586. TRACK SHOWN ESTIMATED FROM RECOVERY POINT AND EXISTING WEATHER PATTERN. MEAN ALTITUDE OF FLIGHT 31,000 FEET OBTAINED FROM RECOVERED BAROGRAPH.
0147-33.0
0211-33.2
0314-33.0
0422-32.1
0445-31.8
1151-31
1334-32.4
1401-31.7
1501-29.2
1533-30.1
1556-29.3
1642-30.7
0600-31.7
0835-31.2
1531-30.8
1618-31.5
1708-30.1
0042-28.3
0110-28.3
0555-28.4
500 MILES
1000 MILES
IMPACT FLT. 583
24.2 HRS OF FLIGHT
3
POSITION FIXES FROM AIRCRAFT TRACKING
POSITION FIXES MADE BY F.C.C
MOUNTAIN STANDARD TIME
UNDERLINED NUMBERS DENOTE ALTITUDE IN THOUSANDS OF FEET
STATUTE MILES
100
50
0
100
200
300
NEBRASKA
KANSAS
MISSOURI
OKLAHOMA
ARKANSAS
NEW MEXICO
ARIZONA
LANDER
CASPER
SIOUX FALLS
DUBUQUE
LA CROSSE
DES MOINES
OMAHA
NORTH PLATTE
LOWRY AIR FORCE BASE
NAS DENVER
SHERMAN AIR FORCE BASE
KANSAS CITY
COLUMBIA
ST LOUIS
DODGE CITY
WICHITA
ENID
TULSA
OKLAHOMA CITY
AMARILLO
ALBUQUERQUE
ROSWELL
EL PASO
DOUGLAS
PHOENIX
FORT WORTH
DALLAS
NAS DALLAS
LITTLE ROCK
BARKSDALE AIR FORCE BASE
JACKSON
DR D.R.
DATE 12-31-52

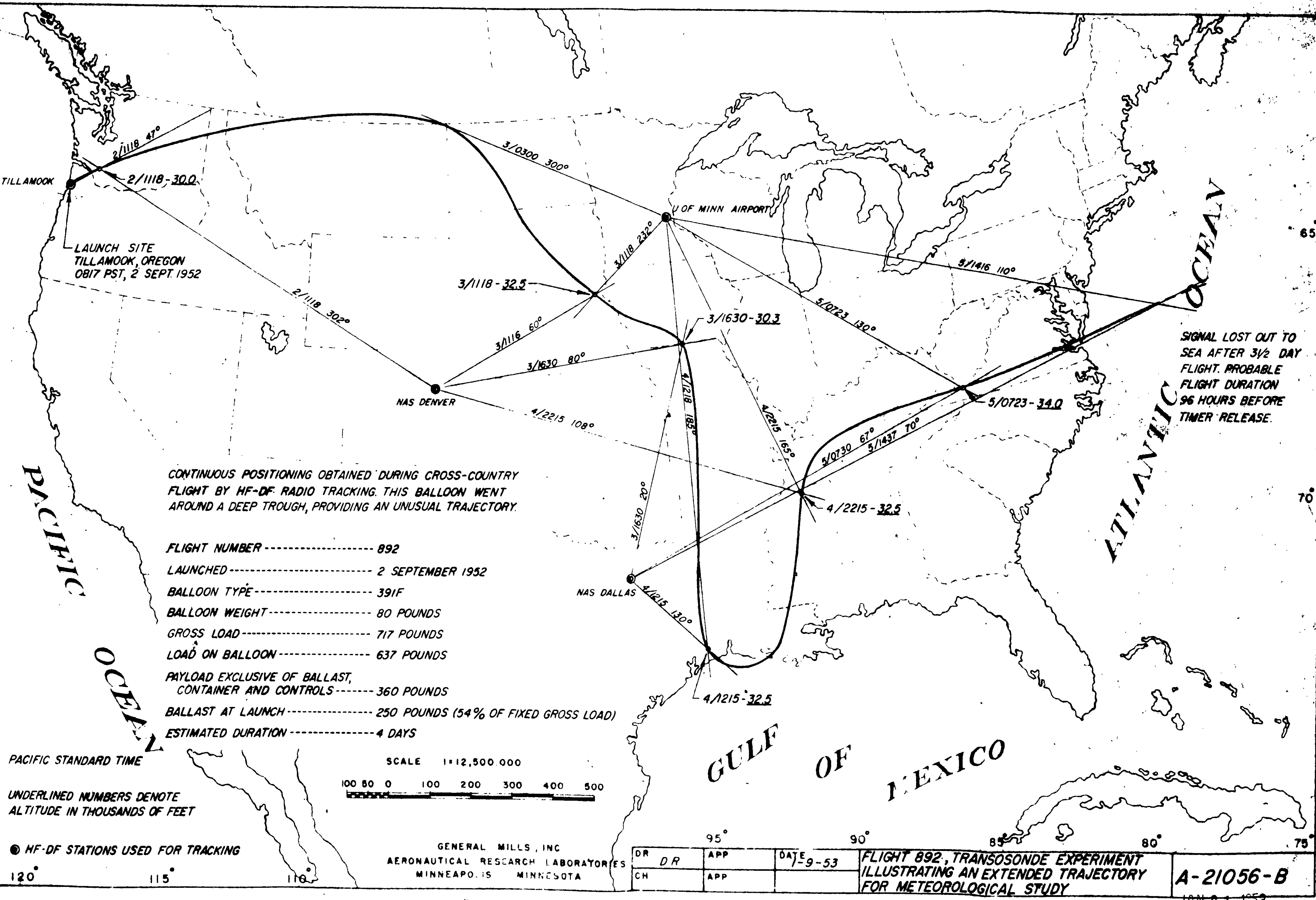


DR	APP	SCALE	
DR		1:5,000,000	GROUND TRACKS OF FIVE SUCCESSIVE 300 MB CONSTANT LEVEL FLIGHTS LAUNCHED DURING A TWO DAY PERIOD
DATE 12-31-52	APP	PROJ J-202	A-20447-D

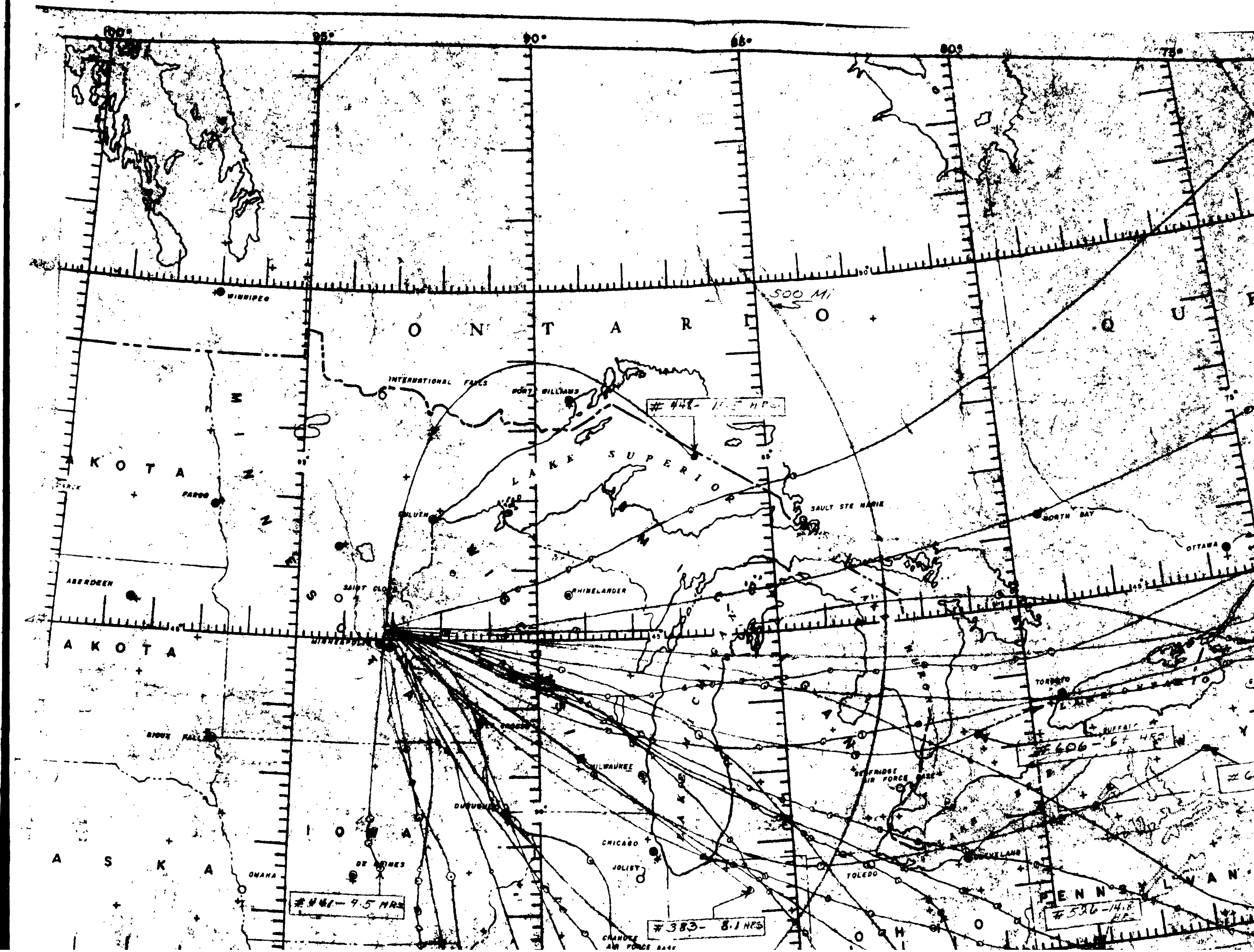
GENERAL MILLS AERONAUTICAL RESEARCH LABORATORY, MINNEAPOLIS, MINNESOTA

JAN 21 1953

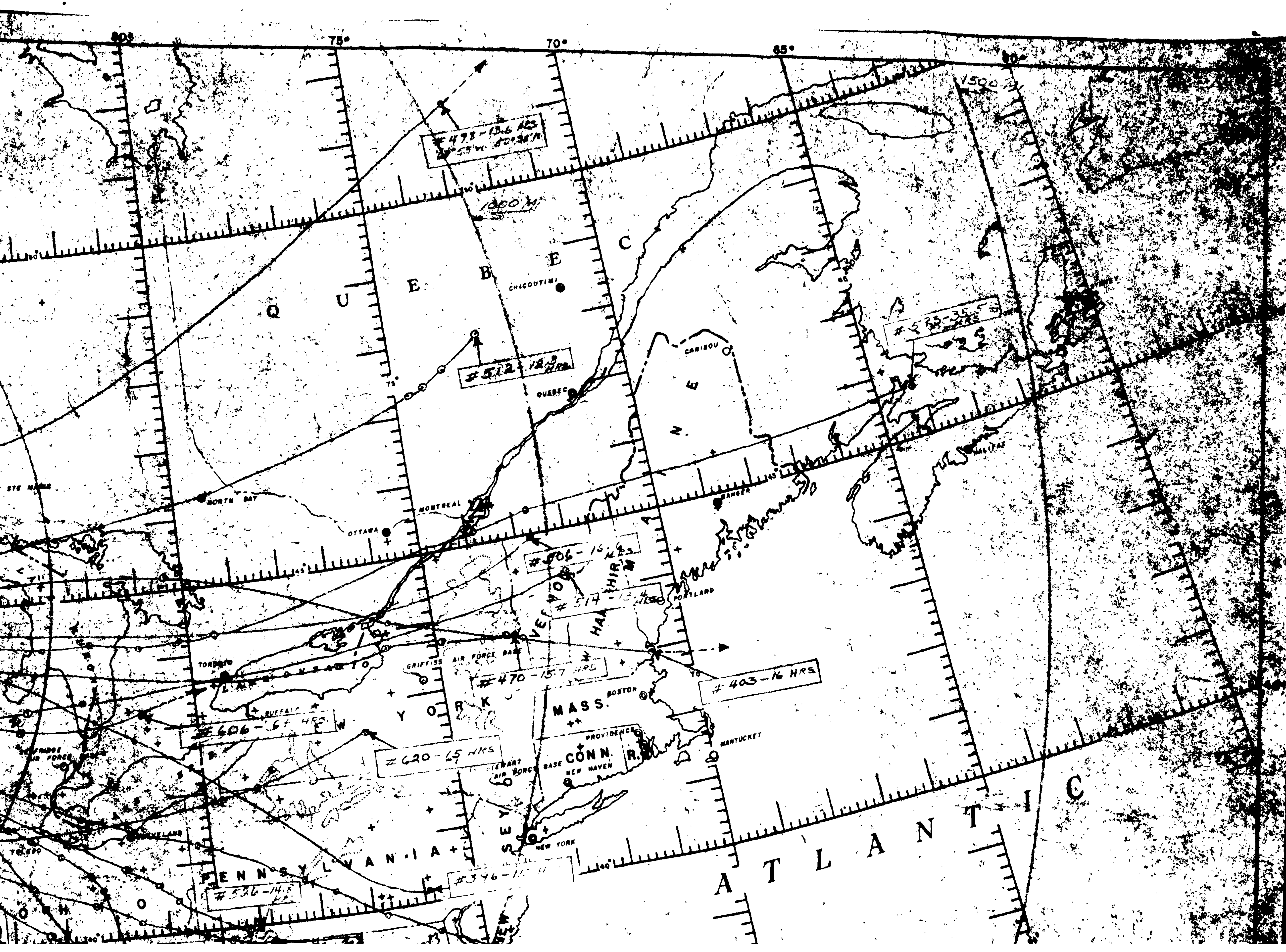

TRANSOSONDE EXPERIMENT
FLIGHT 896
ARCTIC
NORTH POLE
OCEAN
EUROPE
AFRICA
NORTH
AMERICA
ATLANTIC
OCEAN
IMPACT, SALAMANCA, SPAIN
29 SEPT. 1952
ESTIMATED TOTAL DISTANCE TRAVELED - 7000 MILES
PURPOSE: AN EXPERIMENTAL TRANSOSONDE FLIGHT
RESEARCH LABORATORY TO EVALUATE THE
UTILIZING CONSTANT LEVEL BALLOONS FOR
OVER AN INACCESSIBLE AREA SUCH AS THE
CRITIQUE: THIS BALLOON FLIGHT EFFECTIVELY MAINTAINED THE 300 MILLIBAR
PRESSURE LEVEL THROUGHOUT AND IS THE LONGEST
CONSTANT-LEVEL FLIGHT ACHIEVED TO DATE.
IN MADRID, SPAIN REPORTED THAT BALLOON AND
WERE FOUND ON 29 SEPTEMBER 1952. FLIGHT WAS TRACKED
BY RDF ACROSS CANADA AND U.S.A. AND THE REMAINDER OF
TRACK WAS ESTIMATED FROM AVAILABLE WIND DATA.
FLIGHT NUMBER---------------896
LAUNCHED---------------23 SEPTEMBER
BALLOON TYPE
BALLOON WEIGHT---------------70
GROSS LOAD
LOAD ON BALLOON---------------607
PAYLOAD EXCLUSIVE OF BALLAST, CONTAINER AND CONTROLS---332 POUNDS
BALLAST AT LAUNCH---------------250 POUNDS (59% OF
ESTIMATED DURATION
MAXIMUM BALLAST CONSUMPTION---8% OF
(THIS INDICATES LOSS OF GAS DUE TO LEAKAGE
AS THIS IS THE BALLAST REQUIREMENT
LAUNCH SITE
TILLAMOOK, OREGON
2000 PST, 23 SEPT. 1952
26/1108-33.3
26/2010-33.6
27/1008-35.0
27/1506-31.3
PACIFIC STANDARD TIME
UNDERLINED NUMBERS DENOTE
ALTITUDE IN THOUSANDS OF FEET
SCALE TRUE ALONG
632 MILES TO THE
GENERAL
AERONAUTICAL
MINNEAPOLIS
JAN 21

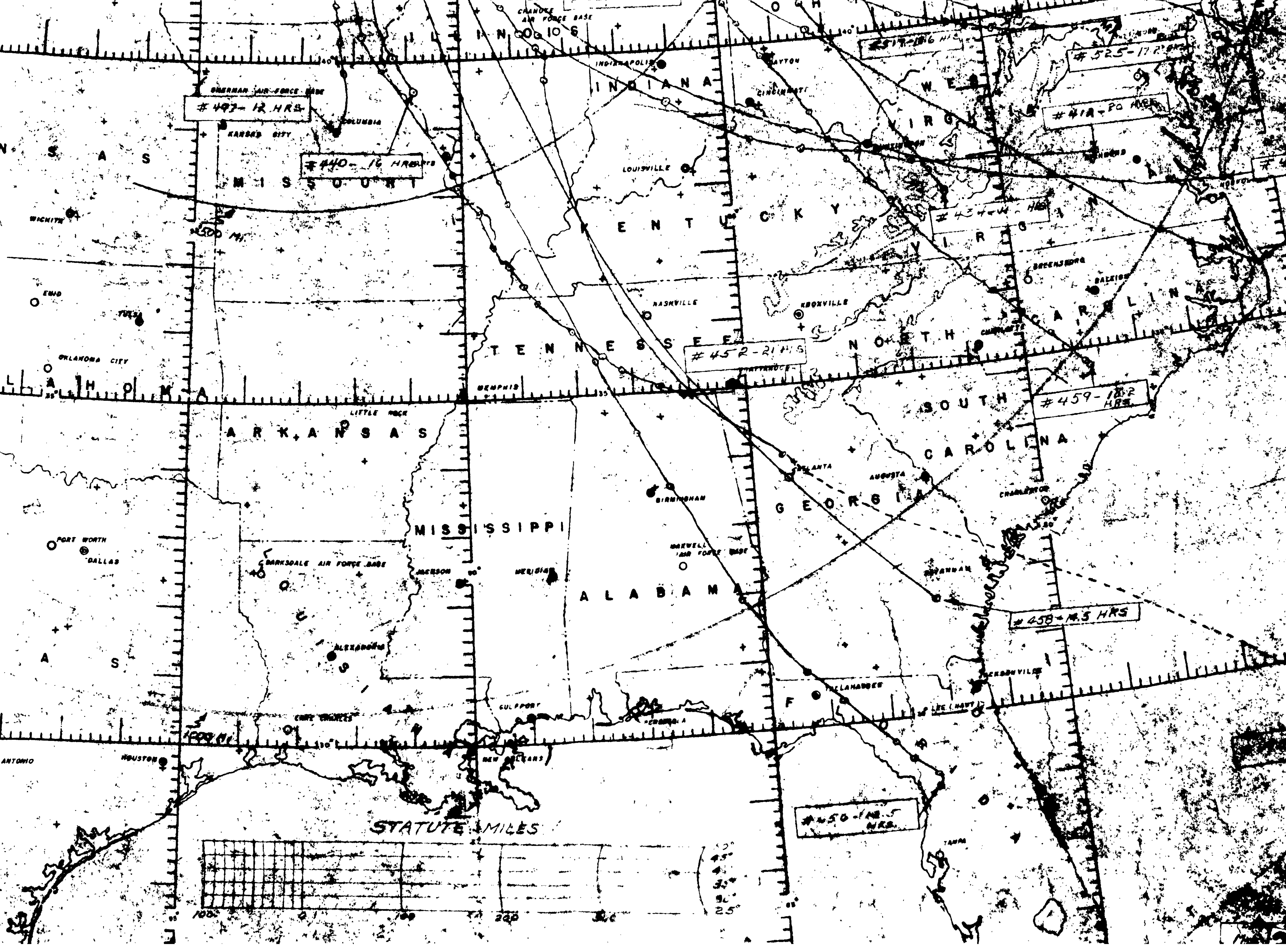


TILLAMOOK
2/1118 47°
2/1118-30.0
LAUNCH SITE
TILLAMOOK, OREGON
0817 PST, 2 SEPT. 1952
3/0300 300°
U OF MINN AIRPORT
3/1118 232°
3/1118-32.5
2/1118 302°
3/1116 60°
3/1630-30.3
3/1630 80°
NAS DENVER
4/2215 108°
4/1218 185°
4/2215 165°
5/0723 130°
3/1416 110°
5/0723-34.0
5/0730 67°
5/1437 70°
4/2215-32.5
3/1630 20°
NAS DALLAS
4/1215 130°
4/1215-32.5
SIGNAL LOST OUT TO
SEA AFTER 3½ DAY
FLIGHT. PROBABLE
FLIGHT DURATION
96 HOURS BEFORE
TIMER RELEASE.
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
CONTINUOUS POSITIONING OBTAINED DURING CROSS-COUNTRY
FLIGHT BY HF-DF RADIO TRACKING. THIS BALLOON WENT
AROUND A DEEP TROUGH, PROVIDING AN UNUSUAL TRAJECTORY.
FLIGHT NUMBER ------------------- 892
LAUNCHED ------------------------ 2 SEPTEMBER 1952
BALLOON TYPE -------------------- 391F
BALLOON WEIGHT ------------------ 80 POUNDS
GROSS LOAD ---------------------- 717 POUNDS
LOAD ON BALLOON ----------------- 637 POUNDS
PAYLOAD EXCLUSIVE OF BALLAST,
CONTAINER AND CONTROLS ------- 360 POUNDS
BALLAST AT LAUNCH --------------- 250 POUNDS (54% OF FIXED GROSS LOAD)
ESTIMATED DURATION -------------- 4 DAYS
PACIFIC STANDARD TIME
UNDERLINED NUMBERS DENOTE
ALTITUDE IN THOUSANDS OF FEET
HF-DF STATIONS USED FOR TRACKING
SCALE 1:12,500,000
100 50 0 100 200 300 400 500
GENERAL MILLS, INC
AERONAUTICAL RESEARCH LABORATORIES
MINNEAPOLIS MINNESOTA
120° 115° 110° 95° 90° 85° 80° 75°
40 35 30 25 20 65 70
DR DR
CH
APP
APP
DATE 1-9-53
FLIGHT 892, TRANSOSONDE EXPERIMENT
ILLUSTRATING AN EXTENDED TRAJECTORY
FOR METEOROLOGICAL STUDY
A-21056-B
JAN 21 1953

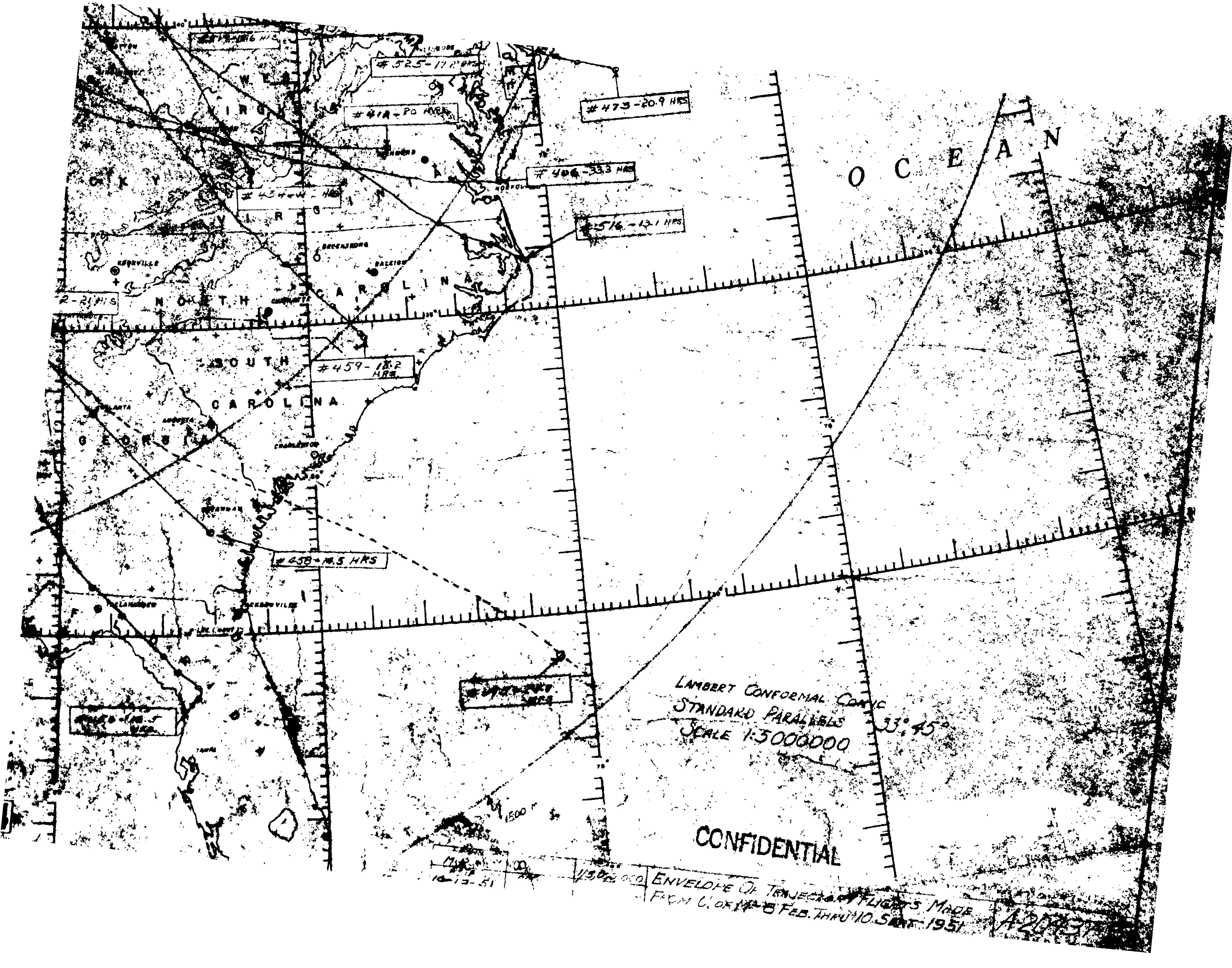


100°
95°
90°
85°
80°
75°
ONTARIO
QUEBEC
LAKE SUPERIOR
500 MI
WINNIPEG
INTERNATIONAL FALLS
PORT WILLIAMS
DULUTH
FARGO
ABERDEEN
SAINT CLOUD
MINNEAPOLIS
RHINELANDER
SAULT STE MARIE
NORTH BAY
OTTAWA
TORONTO
BUFFALO
SELFRIDGE AIR FORCE BASE
MILWAUKEE
DUBUQUE
CHICAGO
JOLIET
TOLEDO
CLEVELAND
CHANUTE AIR FORCE BASE
DES MOINES
OMAHA
SIOUX FALLS
IOWA
OHIO
PENNSYLVANIA
#441- 9.5 HRS
#383- 8.1 HRS
#406- 6+ HRS
#536-14.8 HR.

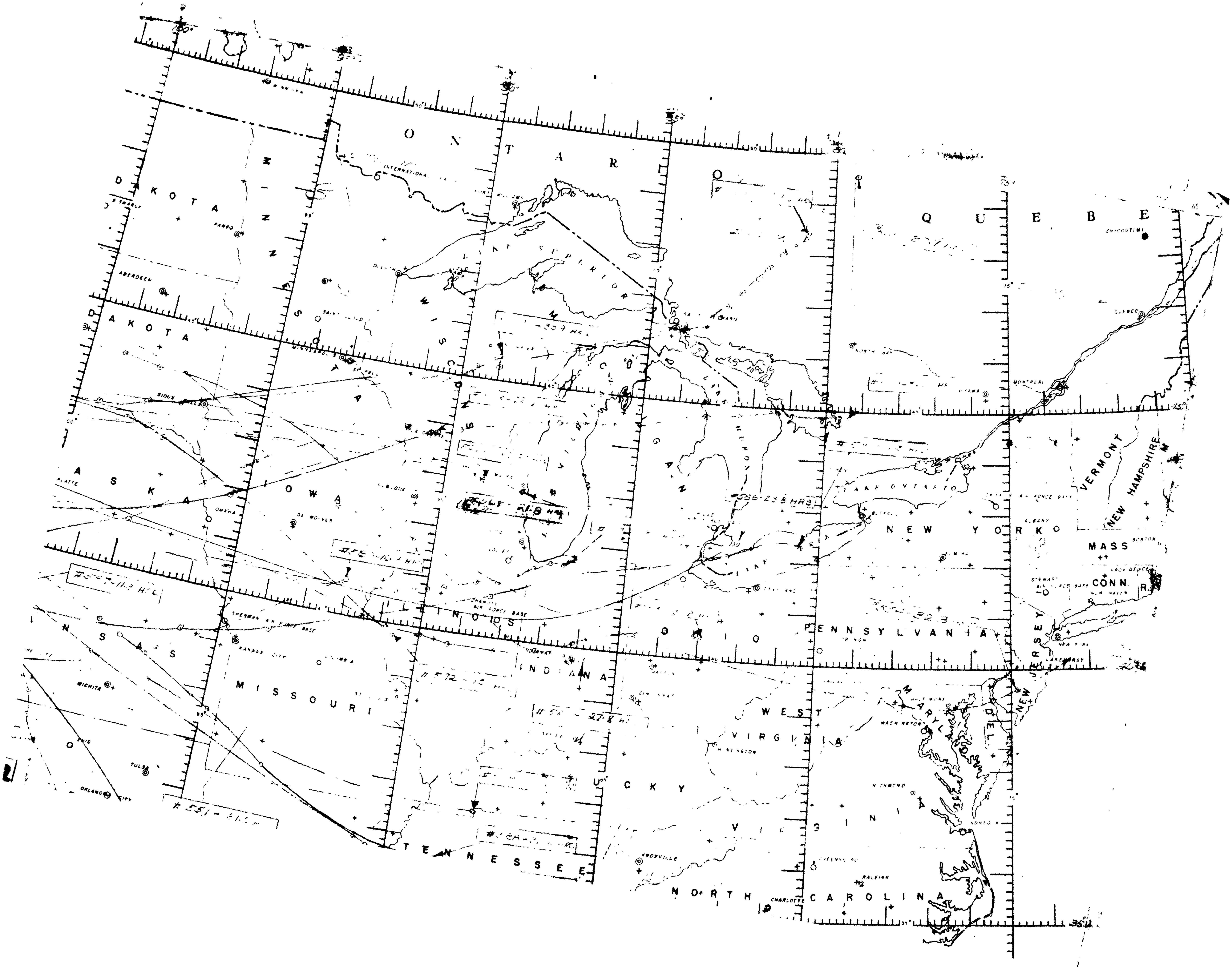

80°
75°
70°
65°
60°
1500 MI
1000 MI
#473 - 13.6 HRS
#512 - 12.8 HRS
#523 - 35.5
#506 - 16.4 HRS
#514 - 13.4 HRS
#470 - 15.7 HRS
#403 - 16 HRS
#406 - 6+ HRS
#620 - 15 HRS
#346 - 11
#536 - 14.8 HR
QUEBEC
CHICOUTIMI
QUEBEC
MONTREAL
OTTAWA
NORTH BAY
STE MARIE
CARIBOU
BANGOR
PORTLAND
BOSTON
PROVIDENCE
NANTUCKET
NEW HAVEN
NEW YORK
TORONTO
BUFFALO
GRIFFISS AIR FORCE BASE
STEWART AIR FORCE BASE
SELFRIDGE AIR FORCE BASE
CLEVELAND
TOLEDO
HALIFAX
SYDNEY
MASS.
CONN.
R.I.
YORK
PENNSYLVANIA
ATLANTIC



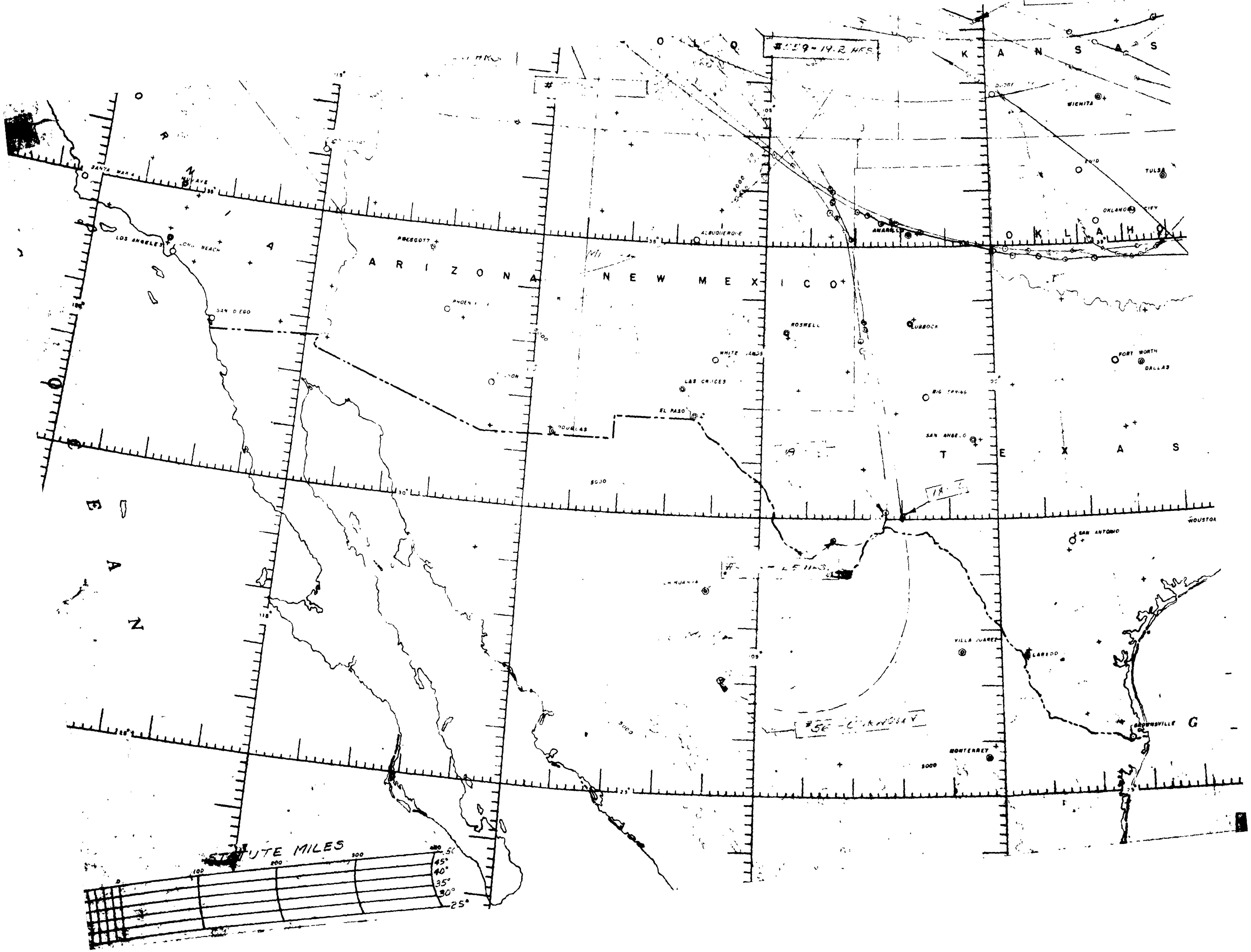
ILLINOIS
INDIANA
INDIANAPOLIS
DAYTON
CINCINNATI
CHANUTE AIR FORCE BASE
WEST VIRGINIA
SHERMAN AIR FORCE BASE
KANSAS CITY
COLUMBIA
MISSOURI
KANSAS
WICHITA
500 MI
LOUISVILLE
KENTUCKY
VIRGINIA
GREENSBORO
RALEIGH
NORTH CAROLINA
ENID
TULSA
OKLAHOMA CITY
OKLAHOMA
NASHVILLE
KNOXVILLE
TENNESSEE
CHARLOTTE
CHATTANOOGA
MEMPHIS
LITTLE ROCK
ARKANSAS
SOUTH CAROLINA
ATLANTA
AUGUSTA
CHARLESTON
BIRMINGHAM
GEORGIA
MISSISSIPPI
FORT WORTH
DALLAS
BARKSDALE AIR FORCE BASE
JACKSON
MERIDIAN
MAXWELL AIR FORCE BASE
SAVANNAH
ALABAMA
LOUISIANA
ALEXANDRIA
TEXAS
JACKSONVILLE
TALLAHASSEE
GULFPORT
LAKE CHARLES
PENSACOLA
NEW ORLEANS
FLORIDA
ANTONIO
HOUSTON
TAMPA
STATUTE MILES
#497- 12 HRS.
#440- 16 HRS
#452-21 HRS
#459- 18.2 HRS.
#458- 14.5 HRS
#456- 14.5 HRS.
#517- 18.6 HRS
#525- 17 HRS
#418- 20 HRS



O C E A N
W E S T V I R G I N I A
V I R G I N I A
K Y
N O R T H C A R O L I N A
S O U T H C A R O L I N A
G E O R G I A
F
#525 - 17 HRS
#418 - 20 HRS
#473 - 20.9 HRS
#406 - 33.3 HRS
#434 - HRS
#516 - 13.1 HRS
#459 - 18.2 HRS
#458 - 14.5 HRS
2 - 21 HRS
NORFOLK
GREENSBORO
RALEIGH
CHARLESTON
JACKSONVILLE
1500
LAMBERT CONFORMAL CONIC
STANDARD PARALLELS 33° 45°
SCALE 1:5000000
CONFIDENTIAL
ENVELOPE OF TRAJECTORY FLIGHTS MADE FROM U. OF M. 8 FEB. THRU 10 SEPT. 1951
1:5000000
10-12-51
A20937



ONTARIO
QUEBEC
CHICOUTIMI
QUEBEC
MONTREAL
DAKOTA
MINNESOTA
FARGO
ABERDEEN
WISCONSIN
LAKE SUPERIOR
MICHIGAN
LAKE HURON
LAKE ONTARIO
LAKE ERIE
IOWA
DE MOINES
OMAHA
SIOUX
PLATTE
ILLINOIS
INDIANA
OHIO
PENNSYLVANIA
NEW YORK
VERMONT
NEW HAMPSHIRE
MASS
BOSTON
CONN.
R.I.
NEW HAVEN
NEW YORK
NEW JERSEY
LAKEHURST
DEL.
MARYLAND
WASH NGTON
WEST VIRGINIA
HUNTINGTON
VIRGINIA
RICHMOND
NORFOLK
KENTUCKY
KNOXVILLE
TENNESSEE
NORTH CAROLINA
RALEIGH
CHARLOTTE
MISSOURI
KANSAS CITY
SHERMAN AIR FORCE BASE
KANSAS
WICHITA
TULSA
OKLAHOMA CITY
NEBRASKA
#556-23.3 HRS



KANSAS
OKLAHOMA
TEXAS
NEW MEXICO
ARIZONA
WICHITA
TULSA
ENID
OKLAHOMA CITY
AMARILLO
ALBUQUERQUE
PRESCOTT
ROSWELL
LUBBOCK
FORT WORTH
DALLAS
BIG SPRING
SAN ANGELO
LAS CRUCES
EL PASO
DOUGLAS
SAN ANTONIO
HOUSTON
LAREDO
VILLA JUAREZ
MONTERREY
BROWNSVILLE
SAN DIEGO
LOS ANGELES
LONG BEACH
SANTA MARIA
MOJAVE
OCEAN
STATUTE MILES
100
200
300
400
50°
45°
40°
35°
30°
25°

ENVELOPE OF TRAJECTORY FLIGHTS MADE FROM HILL AFB - 25 JULY - 27 SEPT - 1951

CONFIDENTIAL

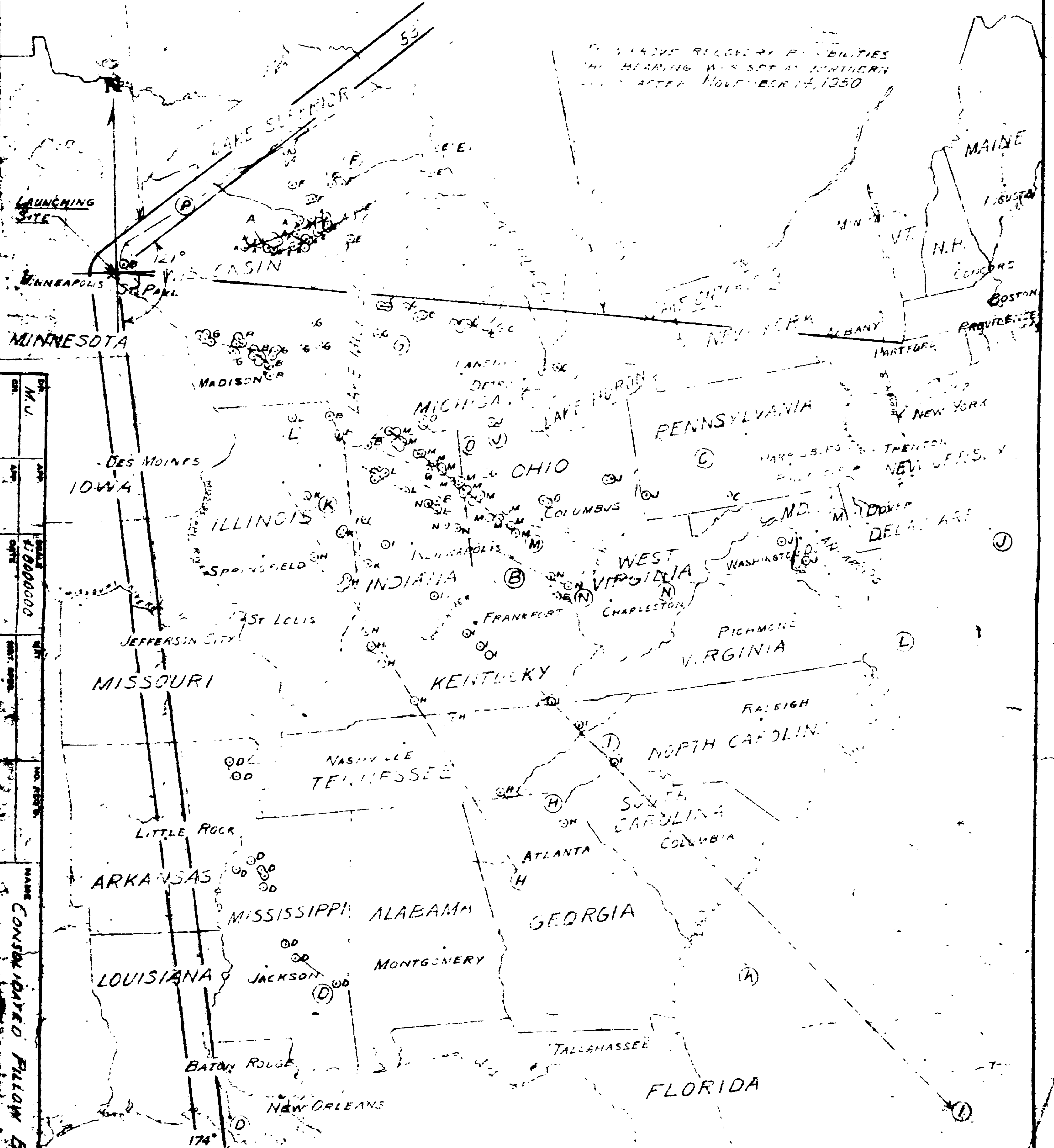
JAN 21 1953

A-20423-D

PILLOW BALLOON DATA

NOTE:
1. FORECAST FLIGHT TRACKS ARE SHOWN WITH DASHED LINES. THE ENDS OF THESE INDICATE THE ESTIMATED MINIMUM AND MAXIMUM BALLOON TRAVEL OF A CLUSTER OF PILLOWS.
2. SOLID LINES INDICATE ACTUAL MEAN TRAJECTORIES THROUGH IMPACT POINTS

— PROBABLE WINTER ENVELOPE OF PILLOW BALLOON TRAJECTORIES POSSIBLE FROM MINNEAPOLIS (50 ITS : 21 P.20 FLIGHTS AT ABOUT 35,000 Ft.)



* TIME IS IN HOURS

CODE	DATE	No. FLOWN	No. RECOV'D	*EST. MEAN DUR.	CODE	DATE	No. FLOWN	No. RECOV'D	*EST. MEAN DUR.
A	10-25-50	20	12	3.8	J	11-30-50	20	6	9.9
B	10-27-50	20	17	4.2	K	12-12-50	20	4	6.3
C	10-30-50	20	13	6.2	L	12-13-50	20	6	5.8
D	11-24-50	20	10	11.5	M	12-15-50	100	28	7.1
E	11-2-50	20	15	3.8	N	12-20-50	20	5	8.2
F	11-7-50	20	8	3.7	O	12-15-49	5	5	7.6
G	11-10-50	20	14	3.1	P	11-14-50	20	0	...
H	11-20-50	20	11	8.8					
I	11-28-50	20	9	9.6					

NAME: CONSOLIDATED PILLOW BALLOON TRACKS

GENERAL MILLS, INC. AERONAUTICAL RESEARCH LABORATORY

DR. M.J. | SCALE 1:8000000 | JAN 7 1953

Recovery Chart
Cluster Flight 30 October 1950
GM P-20 Balloons

#296

Balloon Gross Weight - 207 gms.
Free Lift - 27 gms.
Theor. Floating Altitude - 32,000 Feet
Payload - 28 gms.
Volume - 20 cu. ft.

Launched - 1558

Balloon Number	Date Found	Time Found	Distance & Direction From Nearest Town	Landing Seen?	Gas In Balloon?	
3040	10-31-50	0930	East Prov. Township near Mattie, Pennsylvania	Yes	No	
3041						
3042	10-31-50	0945	20 Miles So., 10 Miles East Sarnia, Ontario	No	Yes	✓
3043						
3044	11-5-50	1200	1 Mile West Fountain, Michigan	No	[illegible]	✓
3045						
3046						
3047						
3048	12-10-50	1000	19 Miles West Midland, Michigan	No	No	
3049	10-31-50	1600	10 Miles South, 2 Miles East Manistee, Michigan	No	Yes	✓
3050	10-31-50	1700	7½ Miles North East St. Louis, Michigan	No	No	✓
3051						
3052	10-31-50	0800	4 Miles East, 2 Miles No. Saginaw, Michigan	No	Yes	✓
3053	11-19-50	1030	7 Miles So. 1½ Miles East Evart, Michigan	No	Yes	
3054						
3055	11-17-50	1200	1 Mile South Hershey, Michigan	No	No	
3056	10-31-50	0615	8 Miles West Caro, Michigan	No	Yes	✓
3057	11-4-50	1200	Sec 23 Lee Township 9 Mi. W, 1¼ Mi. S Midland, Michigan	No	No	✓
3058	11-19-50	1400	1 Mile North Hoxeyville, Michigan	No	No	
3059	12-4-50	1500	No Carter Rd. 8 Miles Midland Michigan	No	Yes	

IF NOT SPECIFIED TOLERANCES ARE:
±.001" IF 3 DECIMAL FIGURES ARE GIVEN
±.01" IF 2 DECIMAL FIGURES ARE GIVEN
±.1" IF 1 DECIMAL FIGURE IS GIVEN

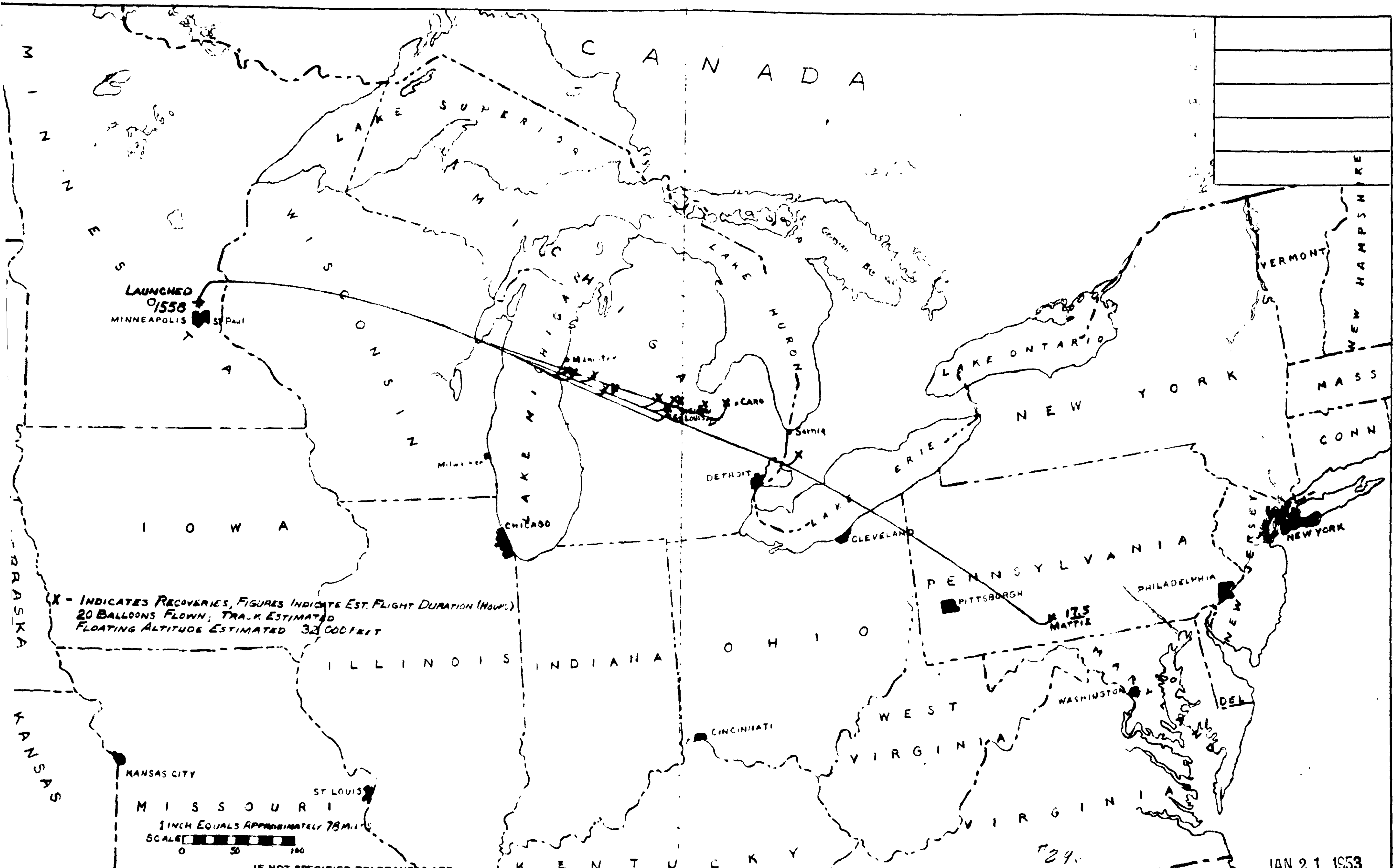
Name: Recovery Chart Cluster Flight 10-30-50

Dr. Darrell Date 10-30-50

A-6276-A

GENERAL MILLS, INC. AERONAUTICAL RESEARCH LABORATORY MINNEAPOLIS, MINN.

JAN 21 1953



JAN 21 1953

IF NOT SPECIFIED TOLERANCES ARE:
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±.01" IF 2 DECIMAL FIGURES ARE GIVEN
±.1" IF 1 DECIMAL FIGURE IS GIVEN

DR DARRELL	APP	SCALE 1" 78 MI	MAT
CH	APP	DATE 11-6-50	MAT SPEC

NO. REQ'D.

NAME PATHS, CLUSTER FLIGHT P-20 BALLOONS, FLOWN 30 OCT. 1950 A-19902

A-6347-B

GENERAL MILLS, INC. AERONAUTICAL RESEARCH LABORATORY MINNEAPOLIS

RECOVERY CHART
CLUSTER FLIGHT 27 OCTOBER 1950
GM P-20 BALLOONS

#295

BALLOON WEIGHT (NOMINAL) - 192 gms.
FREE LIFT - 27 gms.
THEOR. FLOATING ALTITUDE - 32,000 Ft.
PAYLOAD - 28 gms.
VOLUME - 20 cu. ft.

LAUNCHED - 1529

BALLOON NUMBER	DATE FOUND	TIME FOUND	DISTANCE & DIRECTION FROM NEAREST TOWN	LANDING SEEN?	GAS IN BALLOON?
3020	10-28-50	1000	1 MILE NORTH OF UPLAND, INDIANA	NO	YES
3021	10-28-50	0600	5 MILES WEST ASHLAND, KENTUCKY	NO	NO
3022	10-28-50	0830	12 MILES SOUTHEAST MADISON, WISCONSIN	NO	YES
3023	10-28-50	0600	1 MILE EAST LODI, WISCONSIN	NO	YES
3024	10-28-50	1145	7 MILES NE MADISON 3 MILES SW SUN PRAIRIE WIS.	NO	YES
3025	10-28-50	0630	2½ MILES SOUTH UPLAND, INDIANA	NO	YES
3026	10-28-50	0600	HIGHWAY DM, ¼ MILE NORTH DANE, WISCONSIN	NO	YES
3027	10-28-50	1015	5½ MILES SOUTH MAUSTON, WISCONSIN	JUST LANDED	YES
3028	10-28-50	0645	73RD & COLES ST. CHICAGO, ILLINOIS	NO	YES
3029					
3030	10-28-50	1030	201 SHERIDAN ROAD KENILWORTH, ILLINOIS ½ MILE NO. WILMETTE HARBOR	NO	YES
3031	10-27-50	1700	3/4 MILE NORTH 1½ MILE WEST HUGO, MINNESOTA	NO	YES
3032	10-28-50	0700	5 MILES NORTHEAST CHESTERTON, INDIANA	NO	YES
3033	10-28-50	0700	4 MILES SOUTH HGWY. O MAUSTON, WISCONSIN	NO	NO
3034	10-29-50	0850	4 MILES NORTHEAST MERRIMAC, WISCONSIN	NO	YES
3035	11-18-50	1200	4½ MILES WEST WISCONSIN DELLS	NO	NO
3036					
3037	10-29-50	0600	2 MILES WEST BARABOO, WISCONSIN	NO	NO
3038					
3039	11-1-50	0930	7½ MILES NORTH LAVALLE, WISCONSIN	NO	YES

IF NOT SPECIFIED TOLERANCES ARE:
±.001" IF 3 DECIMAL FIGURES ARE GIVEN
±.01" IF 2 DECIMAL FIGURES ARE GIVEN
±.1" IF 1 DECIMAL FIGURE IS GIVEN

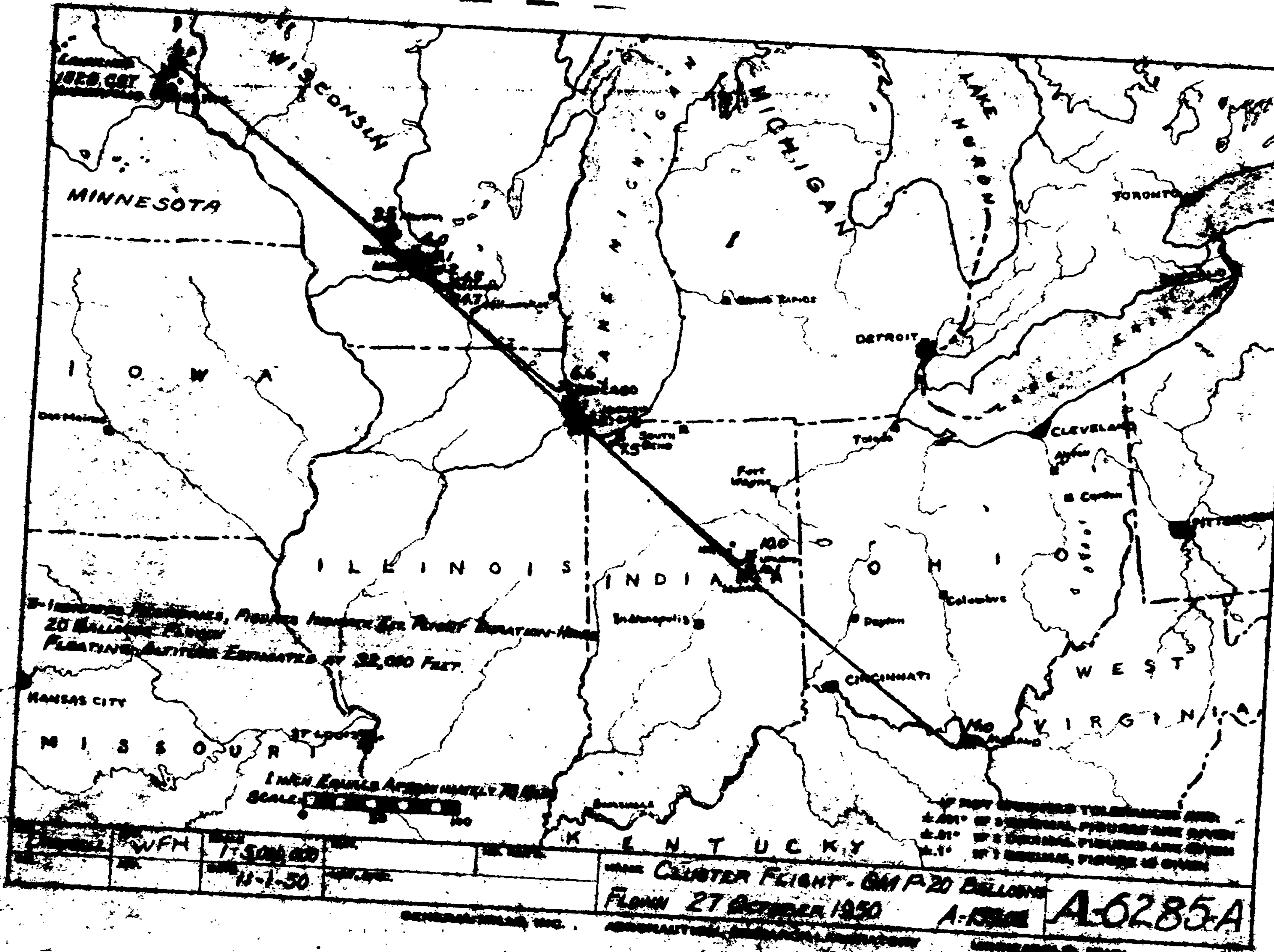
NAME: RECOVERY CHART CLUSTER FLIGHT 10-27-50

A-6275-A

GENERAL MILLS, INC. AERONAUTICAL RESEARCH LABORATORY MINNEAPOLIS, MINN.

DR. DARRELL | DATE 10-30-50

JAN 21 1953


MINNESOTA
WISCONSIN
MICHIGAN
LAKE MICHIGAN
LAKE HURON
TORONTO
IOWA
Des Moines
ILLINOIS
INDIANA
OHIO
WEST VIRGINIA
KENTUCKY
MISSOURI
KANSAS CITY
ST LOUIS
DETROIT
CLEVELAND
Toledo
Fort Wayne
South Bend
Indianapolis
Dayton
Columbus
Canton
CINCINNATI
1826 CST
WFH
1:5,000,000
11-1-50
CLUSTER FLIGHT - GM P-20 BALLOONS
FLOWN 27 OCTOBER 1950
A-6285-A
JAN 21 1953

RECOVERY CHART
CLUSTER FLIGHT 20 NOVEMBER 1950
GM P-20 BALLOONS

#317

BALLOON GROSS WEIGHT -
FREE LIFT - 50 gms.
THEOR. FLOATING ALTITUDE - 32,000 Ft.
PAYLOAD - 28 gms.
VOLUME - 20 Cu. Ft.

LAUNCHED - 1435

1½ MIL

BALLOON NUMBER	DATE FOUND	TIME FOUND	DISTANCE & DIRECTION FROM NEAREST TOWN	LANDING SEEN?	GAS IN BALLOON?
3161	4-15-51	1030	2 MILES S E ATWOOD, ILL	NO	NO
3162	11-30-50	0800	1 MILE FROM OHIO RIVER 17 MILES EAST EVANSVILLE, [illegible]	NO	NO
3163	11-21-50	1800	17 MILES SOUTH OWENSBORO, KENTUCKY	NO	YES
3164	11-21-50	0700	10 MILES SOUTH MARTINSVILLE, ILLINOIS	NO	YES
3165	12-21-50	1430	5 MILES SOUTH CLEVELAND, TENN.	NO	NO
3166	3-12-51	1630	BRUSH CREEK, TENN. 12 MILES FROM CARTHAGE	NO	NO
3167					
3168	11-21-50	EST 0630	2½ MILES NORTH PENDERGRASS, GEORGIA	NO	YES
3169					
3170	12-25-50	1315	15 MILES NORTHEAST EVANSVILLE, INDIANA	NO	NO
3171					
3172	11-21-50	0800	12 MILES WEST GAINSBORO, TENNESSEE	NO	YES
3173					
3174	11-21-50	1400	9 MILES SOUTH BOWLING GREEN, KENTUCKY 300 yds. WEST of [illegible]	NO	YES
3175					
3176	12-5-50	1020	1¼ MILES EAST WILLOW HILL, ILLINOIS	NO	NO
3177	11-20-45	2345	3 MILES WEST OBLONG, ILLINOIS	NO	YES
3178	12-3-50	—	7 MI WEST TUSCOLA, ILLINOIS 22 MI. NNW MATTOON	NO	NO
~~3179~~	3-29-51	0900	5½ SOUTH, ½ EAST OBLONG, ILLINOIS	NO	NO
~~3180~~	3-19-51	1330	5 MILES SOUTHEAST BRIDGEPORT, ILLINOIS	NO	NO

919 MILES (beside 3168)

NUMBER ILLEGIBLE (beside 3179)

NUMBER ILLEGIBLE (beside 3180)

IF NOT SPECIFIED TOLERANCES ARE:
±.001" IF 3 DECIMAL FIGURES ARE GIVEN
±.01" IF 2 DECIMAL FIGURES ARE GIVEN
±.1" IF 1 DECIMAL FIGURE IS GIVEN

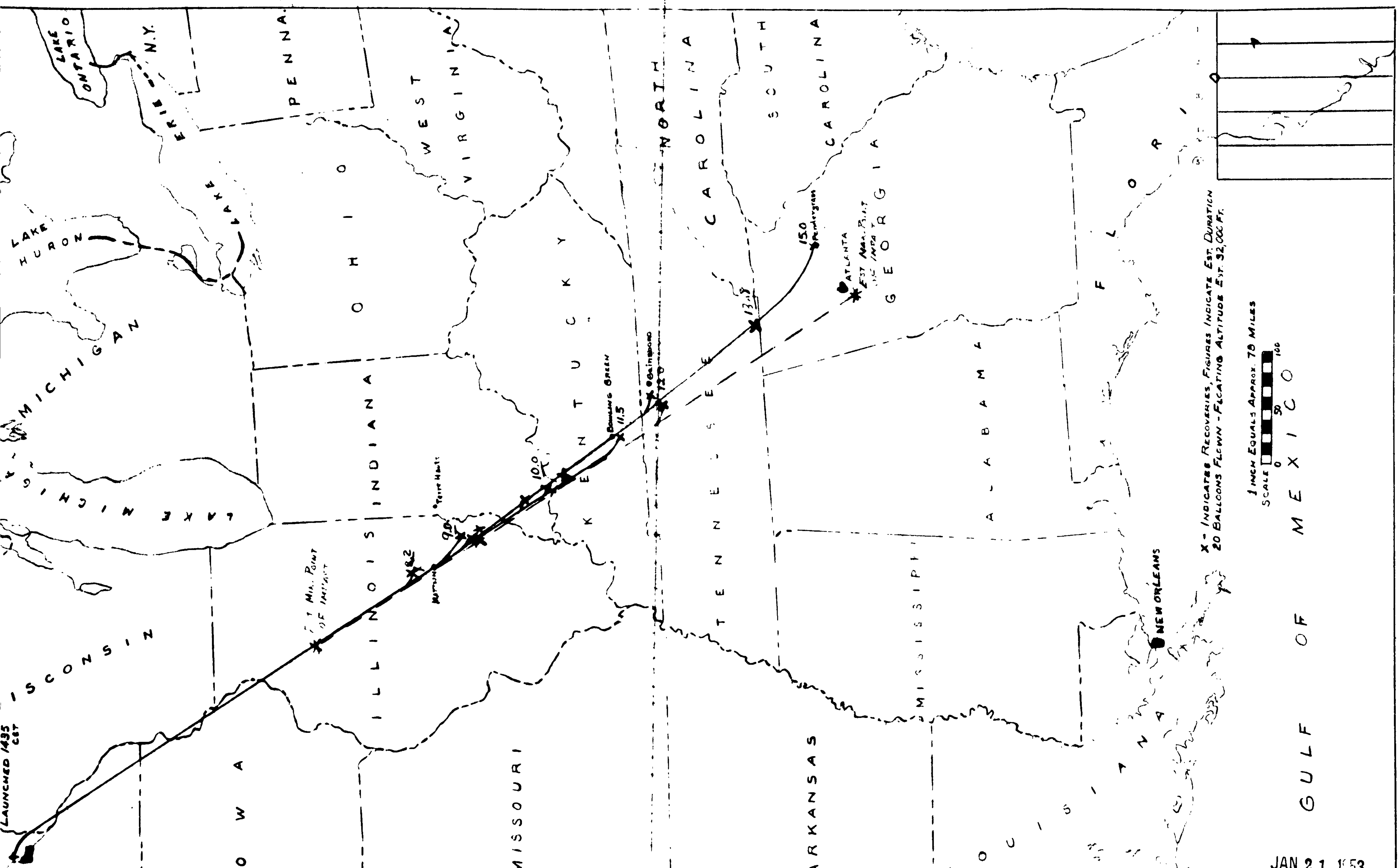
NAME RECOVERY CHART CLUSTER FLIGHT 11-20-50

A-19802 A-6439-A

DR. DARRELL | CH. | APP. | APP. | SCALE | DATE 11-20-50 | MAT. | MAT. SPEC. | NO. REQ'D.

GENERAL MILLS, INC. AERONAUTICAL RESEARCH LABORATORY MINNEAPOLIS, MINN.

JAN 21 1953



JAN 21 1953

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±.001" IF 3 DECIMAL FIGURES ARE GIVEN
±.01" IF 2 DECIMAL FIGURES ARE GIVEN
±.1" IF 1 DECIMAL FIGURE IS GIVEN

DR. DARRELL	APP	SCALE	MAT	NO. REQ'D.	NAME CLUSTER FLIGHT - P-20 BALLOONS
CH.	APP	DATE 11-28-50	MAT. SPEC		FLOWN 20 NOVEMBER 1950 A-199.02

A-6440-B

GENERAL MILLS, INC. AERONAUTICAL RESEARCH LABORATORY MINNEAPOLIS, MINN.

RECOVERY CHART
CLUSTER FLIGHT 15 DECEMBER 1950
GM P-20 BALLOONS

#326

BALLOON GROSS WEIGHT	- 128 grams
FREE LIFT	- 60 grams
THEOR. FLOATING ALTITUDE	- 42,000 FT.
PAYLOAD	- 2.3 grams
VOLUME	- 20 CU. Ft.
	LAUNCHED - 1302

1½ MIL

BALLOON NUMBER	DATE FOUND	TIME FOUND	DISTANCE & DIRECTION FROM NEAREST TOWN	LANDING SEEN?	GAS IN BALLOON?	EST. FLIGHT DURATION (HRS)
3301	4-21-51	1030	7 MI. S.W. ROCKFORD, OHIO	No	No	
3302						
3303	12-16-50	1430	9 MILES WEST FORT WAYNE, INDIANA	No	YES	
3304						
3305	4-25-51	1430	3 SE SIDNEY, OHIO	No	No	
3306	8-2-51	—	SIDNEY OHIO	—	—	
3307						
3308	4-15-51		6.5 MI W.N.W. BUCHANAN, MICH	No	No	
3309						
3310	12-16-50	1030	CINCINNATI OHIO	No	No	
3311	12-16-50	0945	7 MILES SOUTH LONDON, OHIO ROUTE 56	No	YES	
3312	12-16-50	0700	2½ MI NORTH 2½ MI. EAST OSSIAN, INDIANA	No	YES	
3313						
3314						
3315						
3316	12-16-50	1125	1 MILE NORTH, 1½ MI. WEST KETTLERSVILLE OHIO	No	YES	
3317						
3318	12-16-50	1125	1 MILE NORTH 1 MI. WEST KETTERSVILLE OHIO	No	YES	
3319						
3320	12-23-50	1505	1 MILE NORTH CHATTNOOGA, OHIO	No	No	

RECOVERY CHART CLUSTER FLIGHT 12-15-50

A-1302

A-6732A

DARRELL 12-20-50

GENERAL MILLS, INC. AERONAUTICAL RESEARCH LABORATORY MINNEAPOLIS

JAN 21 1953

BALLOON NUMBER	DATE FOUND	TIME FOUND	DISTANCE & DIRECTION FROM NEAREST TOWN	LANDING SEEN?	GAS IN BALLOON?	EST. FLIGHT DURATION (HRS)
3321	12-28-5[illegible]	1430	3 MILES SOUTH SOUTH BEND, IND.	NO	YES	
3322	[illegible]	[illegible]	6 1/2 SE [illegible]	No	No	
3323						
3324						
3325						
3326	12-16-50	1445	2 MILES SOUTHEAST SAINT PARIS, OHIO	NO	NO	
3327	1-5-51	1330	9 MILES SOUTH & EAST COLUMBIA CITY, IND.	NO	NO	
3328	12-17-50	1430	DEWART LAKE 5 MI. SOUTH SYRACUSE, IND.	NO	NO	
3329	12-21-50	1000	8 MILES NORTHWEST COLUMBIA CITY, IND.	NO	NO	
3330	12-16-50	0730	12 MILES SOUTHEAST SIDNEY, OHIO	NO	NO	
3331	12-25-50	1215	4 MILES WEST WAKARUSA, IND.	NO	NO	
3332						
3333	1-20-51		7 MI S.W. FORT WAYNE IND.	No	No	
3334	12-17-50		1/2 MI NW CELINA, OHIO	No	No	
3335						
3336	12-27-50	1500	1 1/2 MI. SAWYER, MICH. 1/2 MI. LAKE MICH. SHORE	NO	NO	
3337						
3338	12-16-50	0800	6 MILES SOUTHEAST SOUTH BEND, IND.	NO	NO	
3339						
3340						
3341	2-24-51	1300	5 MI. SEAST NORTH WEBSTER, IND.	NO	NO	
3342	5-1-51		6 SW [illegible]	No	No	
3343						
3344						
3345	12-16-50	1315	3 MILES NORTHEAST ROCKFORD, OHIO	NO	YES	
3346						

NAME RECOVERY CHART CLUSTER FLIGHT 12-15-50

A-19802

A-6733-A

GENERAL MILLS, INC AERONAUTICAL RESEARCH LABORATORY MINNEAPOLIS, MINN.

JAN 21 1953

NO REQ'D. SCALE DATE 12-20-50 MAT. MAT. SPEC.

DR. DARRELL CH. APP. APP.

Balloon Number	Date Found	Time Found	Distance & Direction from Nearest Town	Landing Seen?	Gas in Balloon?	Est. Flight Duration (hrs)
3347						
3348						
3349						
3350	12-18-50	1530	3 Mi. West 1/4 Mi. South WILLSHIRE, OHIO	No	No	
3351						
3352	3-12-51	0900	3 MILES NORTHWEST ST. PARIS, OHIO	No	No	
3353	12-16-50	1745	22 MILES SOUTHEAST FORT WAYNE, IND. [illegible]	No	No	
3354						
3355						
3356						
3357	[illegible]	[illegible]	[illegible]	[illegible]	No	
3358	12-25-50	1330	NYC RR. 1 1/2 MILES BUCHANAN MICH.	No	YES	
3359	12-18-50	1000	8 MILES NORTHWEST DECATUR, INDIANA	No	No	
3360	3-10-51	1000	10 MILES SOUTHEAST COLUMBIA CITY, INDIANA	No	No	
3361	[illegible]	1508	[illegible] WEST [illegible]	No	YES	
3362	12-16-50	1330	9 MILES SOUTHEAST MISHAWAKA, INDIANA	No	YES	
3363						
3364						
3365	12-16-50	1100	13 MILES EAST SPRINGFIELD BRIGHTON, OHIO	No	YES	
3366	1-5-51	1100	WOODS 7 MILES EAST COLUMBIA CITY, IND.	No	No	
3367	3-6-51	—	4 MILES NORTH W. ROCKFORD, OHIO			
3368						
3369						
3370						
3371						
3372						

NAME: RECOVERY CHART CLUSTER FLIGHT 12-15-50 A-19902

A-6734-A

NO. REQ'D.

MAT.

MAT. SPEC.

SCALE

DATE 12-20-50

DR. DARRELL

CH.

APP.

APP.

AERONAUTICAL RESEARCH LABORATORY

GENERAL MILLS, INC

MINNEAPOLIS, MINN.

JAN 21 1953

BALLOON NUMBER	DATE FOUND	TIME FOUND	DISTANCE & DIRECTION FROM NEAREST TOWN	LANDING SEEN?	[illegible]	EST. FLIGHT DURATION (HRS)
3373						
3374						
3375						
3376						
3377	6-1-51	1730	4 MI FROM ROCKFORD, OHIO	No	No	
3378	12-16-50	1530	3½ MILES NORTHEAST LEESBURG, INDIANA	No	No	
3379						
3380	12-16-50	1700	3½ MILES EAST NEW BREMAN, OHIO	No	No	
3381						
3382						
3383						
3384	3-17-51	1000	4 MILES NORTH COLUMBIA CITY, IND.	No	No	
3385	4-25-51	1000	COLUMBIA CITY, IND	No	No	
3386						
3387	4-18-51		3 MI. S W BUCHANAN, MICH	No	No	
3388						
3389						
3390						
3391	2-25-51	1300	4 MILES SOUTH SOUTH BEND, IND.	No	No	
3392	12-17-50	1145	9 MILES SOUTHEAST COLUMBIA CITY, INDIANA	No	NO TORN	
3393	12-23-50	1430	WOODS, 9 MILES NORTHWEST URBANA, OHIO	No	No	
3394	4-24-51	0400	2½ mi S, 3 mi W ROCKFORD, OHIO	No	No	
3395	6-6-51	1500	6 MI S FT WAYNE, IND	No	No	
3396	4-13-51	1500	13 MI So FORT WAYNE, IND	No	No	
3397						
3398	12-16-50	1230	4 MILES EAST DECATUR IND. ON HGWY 224 1 MI. NO. ON HGWY 101	No	YES	

A-6735-A

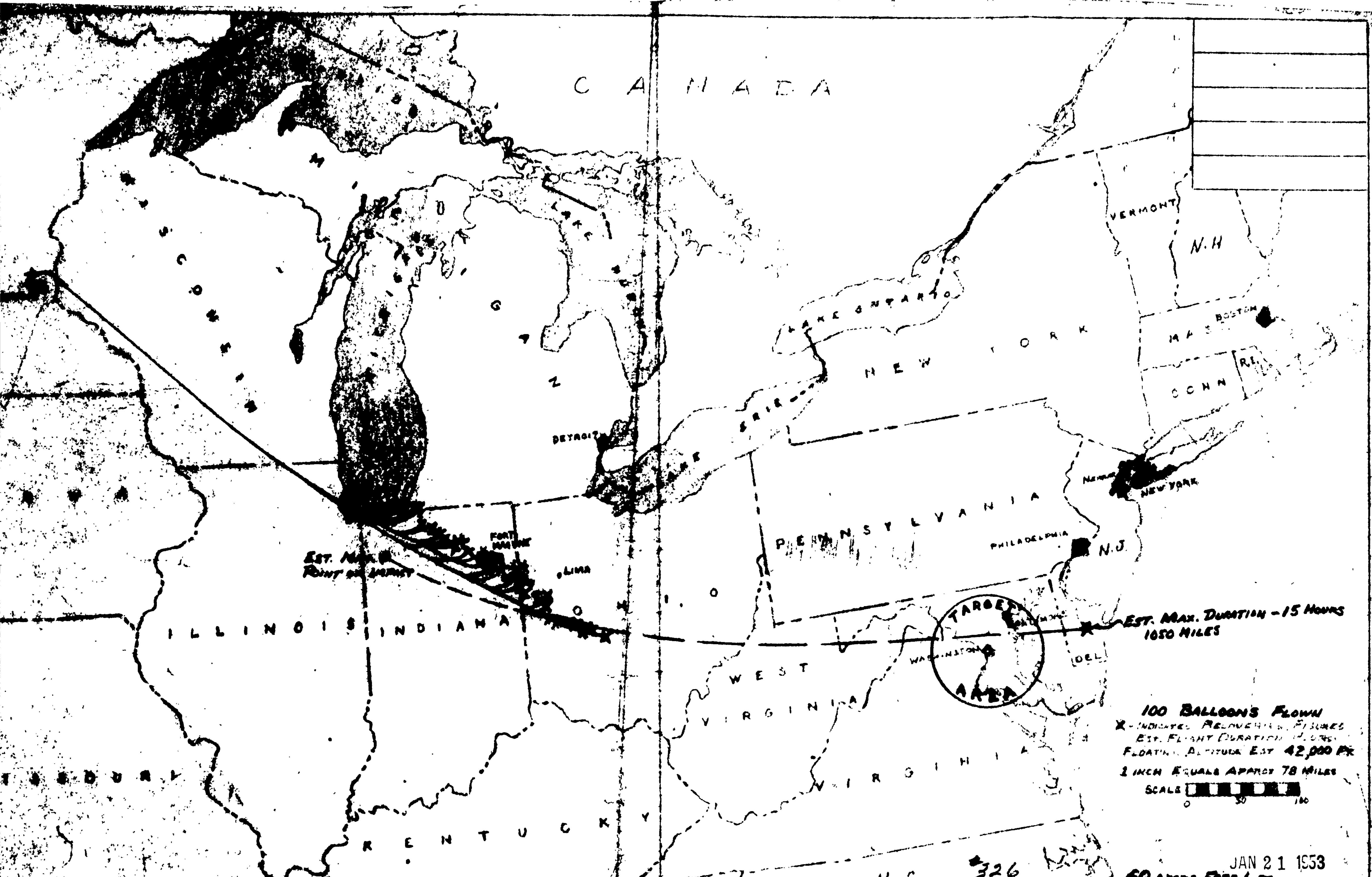
NAME RECOVERY CHART CLUSTER FLIGHT 12-15-50 AMM

NO. REQ'D. | MAT. | MAT. SPEC. | SCALE | DATE 12-20-50 | APP. | APP. | DR. DARRELL

GENERAL MILLS, INC. AERONAUTICAL RESEARCH LABORATORY MINNEAPOLIS, MINN.

JAN 21 1953

#326

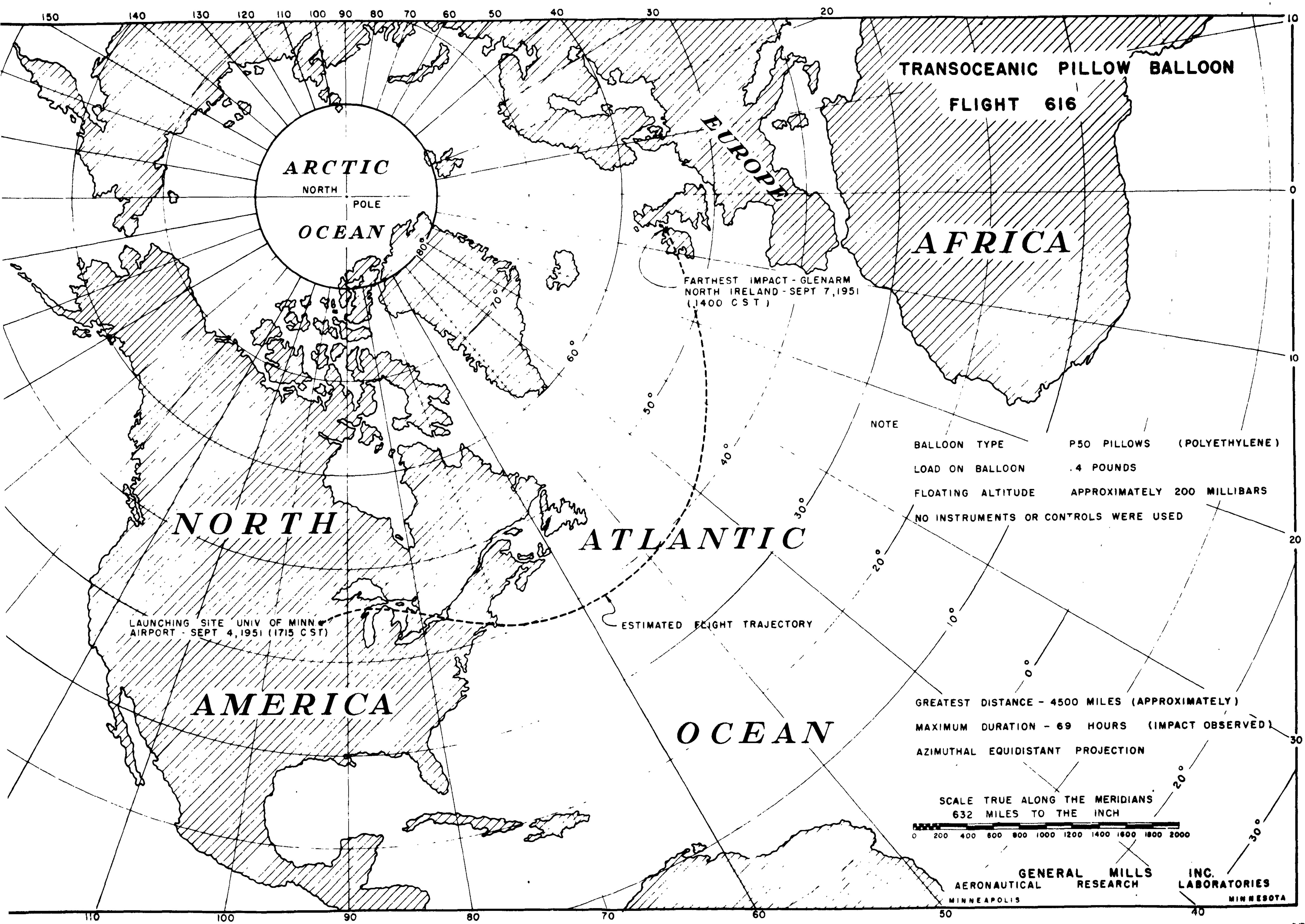


Name: CLUSTER FLIGHT P20 BALLOONS
FLOWN 15 DECEMBER 1950 A-19902

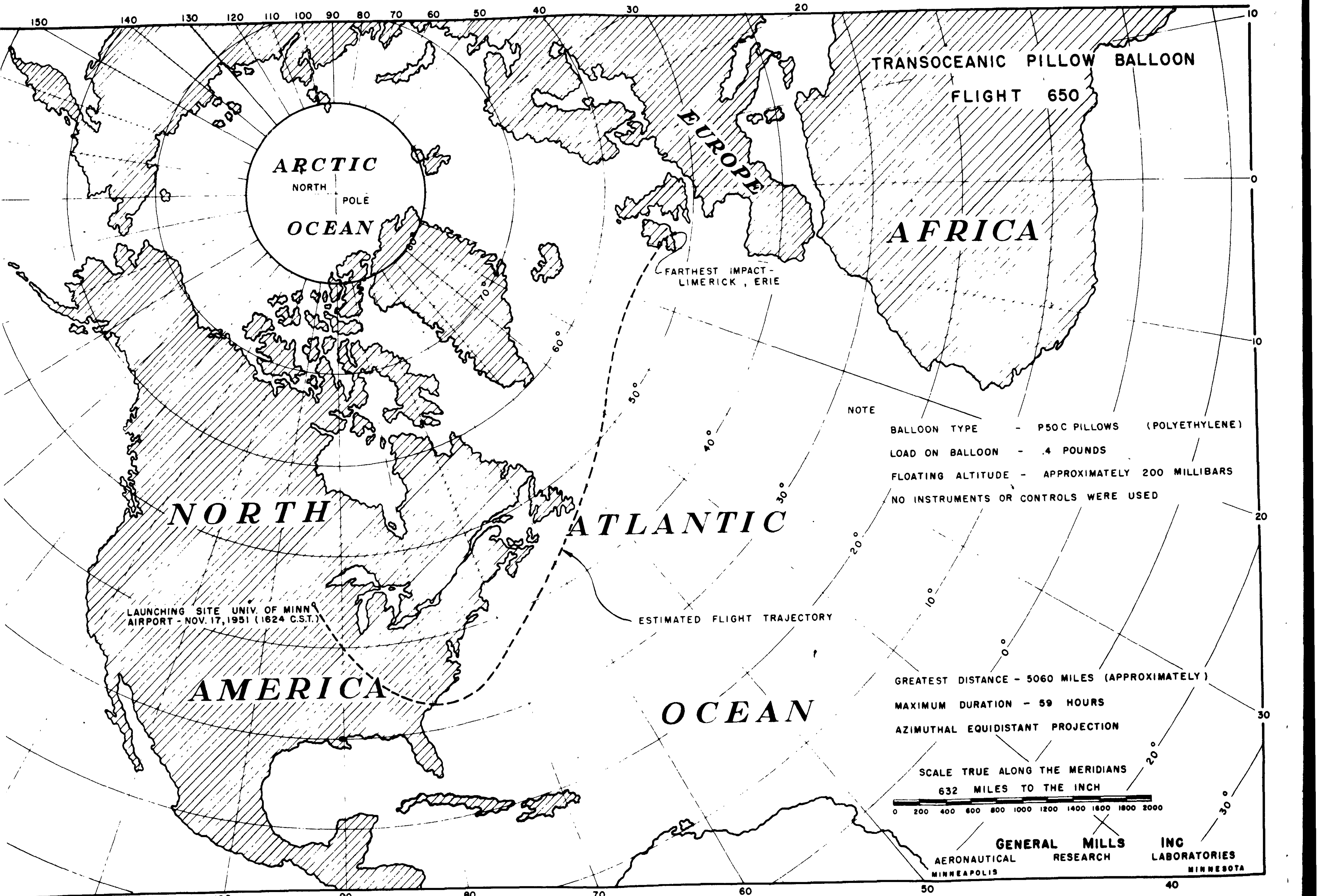
Dr. DARRELL
12-19-50

A-6731-B

GENERAL MILLS, INC. AERONAUTICAL RESEARCH LABORATORY MINNEAPOLIS, MINN.



TRANSOCEANIC PILLOW BALLOON
FLIGHT 616
ARCTIC
NORTH
POLE
OCEAN
EUROPE
AFRICA
FARTHEST IMPACT - GLENARM
NORTH IRELAND - SEPT 7, 1951
(1400 C S T)
NORTH
ATLANTIC
AMERICA
OCEAN
LAUNCHING SITE UNIV OF MINN
AIRPORT - SEPT 4, 1951 (1715 CST)
ESTIMATED FLIGHT TRAJECTORY
NOTE
BALLOON TYPE P50 PILLOWS (POLYETHYLENE)
LOAD ON BALLOON .4 POUNDS
FLOATING ALTITUDE APPROXIMATELY 200 MILLIBARS
NO INSTRUMENTS OR CONTROLS WERE USED
GREATEST DISTANCE - 4500 MILES (APPROXIMATELY)
MAXIMUM DURATION - 69 HOURS (IMPACT OBSERVED)
AZIMUTHAL EQUIDISTANT PROJECTION
SCALE TRUE ALONG THE MERIDIANS
632 MILES TO THE INCH
0 200 400 600 800 1000 1200 1400 1600 1800 2000
GENERAL MILLS INC.
AERONAUTICAL RESEARCH LABORATORIES
MINNEAPOLIS MINNESOTA



TRANSOCEANIC PILLOW BALLOON
FLIGHT 650
ARCTIC
NORTH POLE
OCEAN
EUROPE
AFRICA
FARTHEST IMPACT - LIMERICK, ERIE
NORTH
ATLANTIC
AMERICA
OCEAN
LAUNCHING SITE UNIV. OF MINN AIRPORT - NOV. 17, 1951 (1624 C.S.T.)
ESTIMATED FLIGHT TRAJECTORY
NOTE
BALLOON TYPE - P50C PILLOWS (POLYETHYLENE)
LOAD ON BALLOON - .4 POUNDS
FLOATING ALTITUDE - APPROXIMATELY 200 MILLIBARS
NO INSTRUMENTS OR CONTROLS WERE USED
GREATEST DISTANCE - 5060 MILES (APPROXIMATELY)
MAXIMUM DURATION - 59 HOURS
AZIMUTHAL EQUIDISTANT PROJECTION
SCALE TRUE ALONG THE MERIDIANS
632 MILES TO THE INCH
0 200 400 600 800 1000 1200 1400 1600 1800 2000
GENERAL MILLS INC
AERONAUTICAL RESEARCH LABORATORIES
MINNEAPOLIS MINNESOTA